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MOTOR CARS ON EUROPEAN RAILWAYS.

The use of motor cars on ordinary railways, either to supplement the train service on main lines or to replace it on secondary lines, is a promising proposition, tending towards economy in operation in the latter case, and to the increase of traffic and revenue at little expense in the former case. This class of service has been in regular use in Europe for both the above-mentioned purposes, for a number of years, and some three or four years ago there was a decided movement in favor of introducing it in this country. Experiments were made on half a dozen railways, but were all abandoned in a short time. In our issue of Feb. 6, 1902, we described these several cars and experiments, and since that time no further steps have been taken in the matter, if we except the temporary use of a gasoline car on a small western line. In Europe, however, there has been a steady development in the use of the motor car service, and the most striking feature of this development is the introduction of motor cars by conservative English railways, with results that so far appear to be highly satisfactory. This is due in large measure to the growing competition of electric railways, as pointed out in a discussion of this matter in our issue of Oct. 22, 1903. A special feature of the development in England, and one which is almost unique, is the institution of a service of automobiles on the public roads, the cars being operated by the railway companies in connection with their train service, and serving towns and villages or places of scenic interest which are near the railways, but are not directly reached by them.

In another column we have discussed the general question of motor car service on steam railways, and in the present article we describe some of the recent motor cars and motor-car services of European railways. At the present time this class of service is in operation in England, France, Belgium, Germany, Switzerland, Austria, Hungary, Italy and Russia, while it is also to be introduced on one of the railways in India.

ENGLAND.

LONDON & SOUTHWESTERN RY.—The first step of the recent movement in England towards the use of motor cars on railways was taken last summer by this railway, which built a steam car to operate the branch line between Fratton Junction and Southsea, near Portsmouth. The results were so satisfactory that the system was adopted for the Basingstoke & Alton light railway, and its adoption for other branches is contemplated. The cars were designed by Mr. Dugald Drummond, Locomotive Superintendent, and were built at the company's shops near London. One of them is shown in Fig. 1.

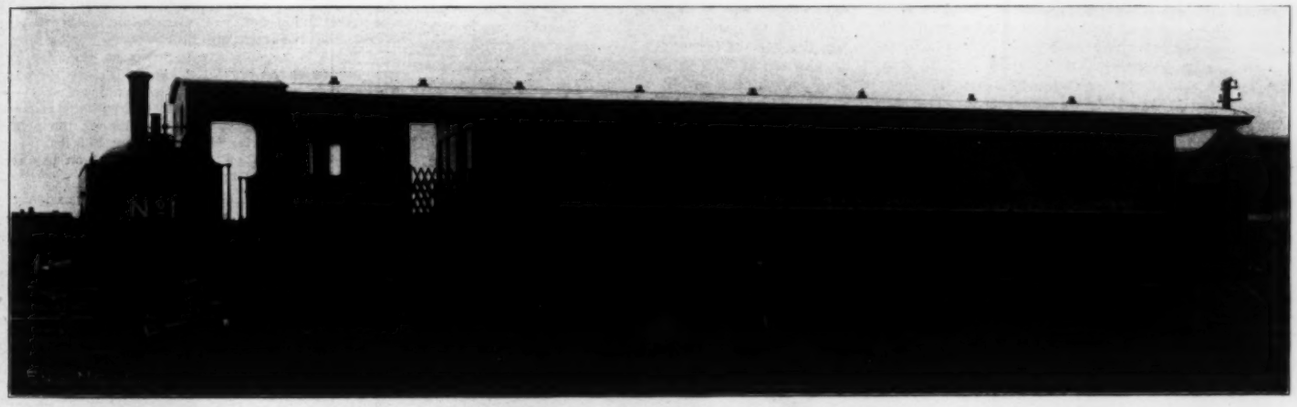


FIG. 1. STEAM CAR OF THE LONDON & SOUTHWESTERN RY., ENGLAND.
Dugald Drummond, Locomotive Superintendent.

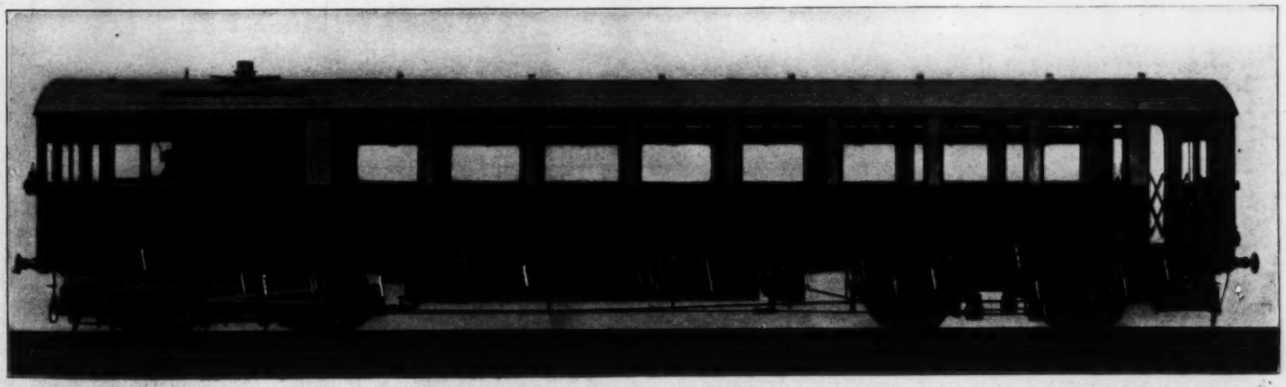


FIG. 3. STEAM CAR OF THE GREAT WESTERN RY., ENGLAND.

At the front end is the boiler, with side tank and coal bunker in front of the cab. Then comes

a short baggage compartment and a gangway (under roof) with door opening into the front end of the second-class passenger compartment, which is called the "third class," since this railway (like several others in England) has reduced the number of classes from three to two by eliminating the second class. At the rear is a platform with entrance to that part of the car for first-class passengers. In the partition between the compartments is a door for the use of the conductor. The gangway and rear platform are closed by folding gates. The car is 56 ft. long over the steel channel sills, weighs 23 tons empty and has a maximum speed of 40 miles an hour. It is mounted on a pair of four-wheel trucks with 8-ft. wheelbase, steel frames and solid-center wheels. It can carry 14 first-class and 32 second-class passengers and 1 ton of baggage.

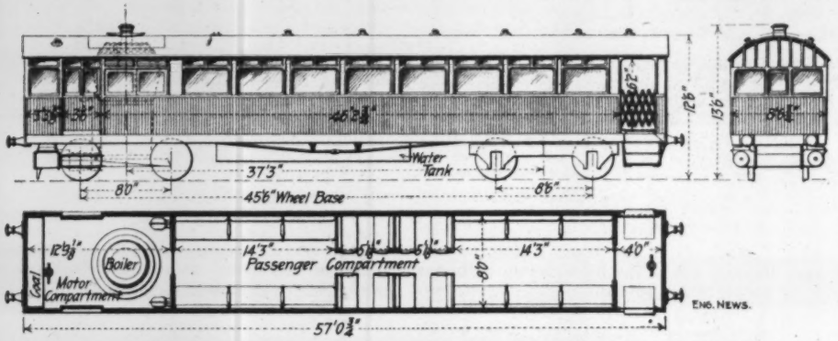


FIG. 2. PLAN AND ELEVATION OF STEAM CAR; GREAT WESTERN RY., ENGLAND.
G. J. Churchward, Locomotive Superintendent.

The boiler is of the locomotive type. The cylinders, 9 × 14 ins., are placed outside, between the truck wheels, and slightly inclined. The connecting rods are fitted to crank pins in the leading wheels, and a return crank carries a rod operating the valve gear. Only the front axle is driven, no coupling rods being used. No flexible steam couplings are required, as the boiler and cylinders are all carried by the truck frame. The power is said to be sufficient to give an acceleration of 30 miles an hour in 30 seconds. The coal consumption is said to have been reduced to 7 lbs. per mile run, and Mr. Drummond informs us that the cost of operation is 4.18 cts. per mile. This figure of cost is inclusive of all wages, coal and other stores, but exclusive of interest on the first cost.

A more complete statement has been published comparing the cost per mile run for operation, maintenance and repairs of the steam car with that of a train of engine and four cars, as used in ordinary branch line service. The comparison is as follows, and shows a saving of nearly 33% in favor of the steam car:

COMPARISON OF MOTOR CAR AND TRAIN SERVICE.

	—Cost, per mile.— Steam-car. Cts.	Train. Cts.
OPERATION—ENGINE:		
Coal	2.72	6.06
Water	.24	.72
Oil and other stores	.38	.92
Cleaning	.14	.66
Raising steam, etc.	.18	.20
Washing out	.06	.16
CAR:		
Lighting	.24	.64
Cleaning	.20	1.10
Oil	.02	.10
REPAIRS AND RENEWALS:		
Engine	1.90	6.96
Cars	1.02	5.50
WAGES:		
Enginemen	2.74	3.92
Traffic men	1.12	2.90
Total	10.96	29.84

GREAT WESTERN RY.—In the summer of 1903, the steam car question was taken up actively, and two cars were built at the company's shops to the designs of Mr. G. J. Churchward, Locomotive Superintendent. The two cars cost $25,000. These were put in service in October between Chalford and Stonehouse, 7 miles, which piece of line has maximum grades of 1.43 and curves of 2,000 ft. radius. There are four intermediate stations, but the cars stop also at intermediate points, having folding steps to reach within easy distance of the ground. The cars make 12 trips per day, as a rule, 14 on Friday and 15 on Saturday. The time allowed for the 7-mile trip is 23 minutes, the average speed being 30 and the maximum speed 45 miles per hour. The fares are lower than on the regular trains. There is only one class of accommodation, and each car carries 52 passengers, but no freight or baggage. The general construction is shown in Figs. 2 and 3. The total length is 57 ft., of which the motor compartment takes 12 ft. 9 ins., the rear vestibuled platform 4 ft. The width is 8 ft. 6¼ ins. over all and 8 ft. inside, while the height is 6 ft. 2 ins. from floor to edge of roof and 12 ft. 6 ins. from rail to top of roof. At the middle of the passenger compartment are four sets of transverse seats, two on each side of the center aisle, as in cars on American elevated railways; for the rest of the space side seats are fitted. This is shown in the interior view, Fig. 4. The car has gas lamps of 16 c. p.; 16 in the passenger compartment, 2 in the motor compartment and one over the rear platform. The gas is stored in cylinders under the car. The total weight is 36½ tons, and car carries two men. There is electrical communication between the end platform and the cab, so that when running platform first the conductor can keep a lookout and signal to the engineman.

The car is mounted on two trucks with a total wheelbase of 45 ft. 6 ins., the front or driving truck having a wheelbase of 8 ft., and the rear truck 8 ft. 6 ins. The wheels are 44 ins. diameter. The boiler, Fig. 5, is of the vertical type, conical in the barrel, with minimum and maximum outside diameters of 4 ft. 6 ins. and 6 ft. It is 9 ft. 6 ins. high and is designed for a working pressure of 180 lbs. per sq. in. with a factor of safety of 4.6. There are 477 tubes 1⅛ ins. diameter, giving 625.58 sq. ft. of heating surface, while the firebox has 44.36 sq. ft., making a total of 669.92 sq. ft. of heating surface. The grate area is 11.48 sq. ft. The area of tube openings is 2.18 sq. ft.; area of boiler at water line, 23.06 sq. ft.; steam space, 24.16 cu. ft. The coal bunker is across the front end of the car, and 450 gallons of water are carried in a cylindrical tank beneath the floor. The cylinders, 12 × 16 ins., are outside, horizontal, placed in front of the leading wheels and driving the rear axle, while the two axles are connected by coupling rods. The valve gear is of the Walschaert type. Hand and vacuum brakes are used.

In the company's report for 1903 it was stated that the Chalford and Stonehouse motor car service had given very good results in developing a large local traffic which did not exist before, and the results were so satisfactory that the company ordered similar cars for use on other parts of the line. According to an English paper these cars have proved so satisfactory that orders have been given to build 24 more at the company's shops, but we are inclined to doubt whether the number stated can be correct. In regard to rapid acceleration and quick stopping, these cars are far superior to a light train. For cars running on the main lines it has been found desirable to employ three men: engineman, fireman and conductor. On branch lines, however, with lighter traffic, it would be quite practicable to dispense with the fireman. From Mr. Churchward we have the following statement:

We have not yet had enough experience of working the two men only on the car, one at the front and one at the rear, to be able to say whether this can be satisfactorily done. You will observe that it is possible to drive the car from either end, and when running the car engine ahead, the two men are in the same compartment, so that there is no difficulty in firing on the road we are running on at the present moment. This is downhill all the way on one trip, so that no sound statistics can be obtained until we have cars we are building at work on other sections. The coal consumption on the particular service we are running is heavy, being 16.5 lbs. per mile, but we expect this to be much reduced on any service of an ordinary character.

GREAT NORTHERN RY.—This railway departed from the example of other English railways but followed some continental precedents in adopting an oil engine instead of a steam engine for a motor car for branch line service. The fuel is petroleum, costing 10 cts. per gallon (when purchased by the barrel) in London. The car, Fig. 6, as described by the builders, has transverse seats on each side of the central aisle and can carry 32 passengers. At one end is a baggage compartment, and there is a motorman's cab at each end. The car is 30 ft. long over the body, and is mounted on four wheels, with a wheelbase of 19 ft. 6 ins. The total weight empty is said to be only about 7½ tons. The engines are

FIG. 4. INTERIOR OF STEAM CAR; GREAT WESTERN RY., ENGLAND.

of 30-HP., with six cylinders arranged in pairs and driving through a friction clutch to the gear box which gives four rates of speed: 6, 11, 20 and 32 miles an hour. The front axle is driven from the countershaft by chain gear. The cylinders of the engine are operated independently, so that at

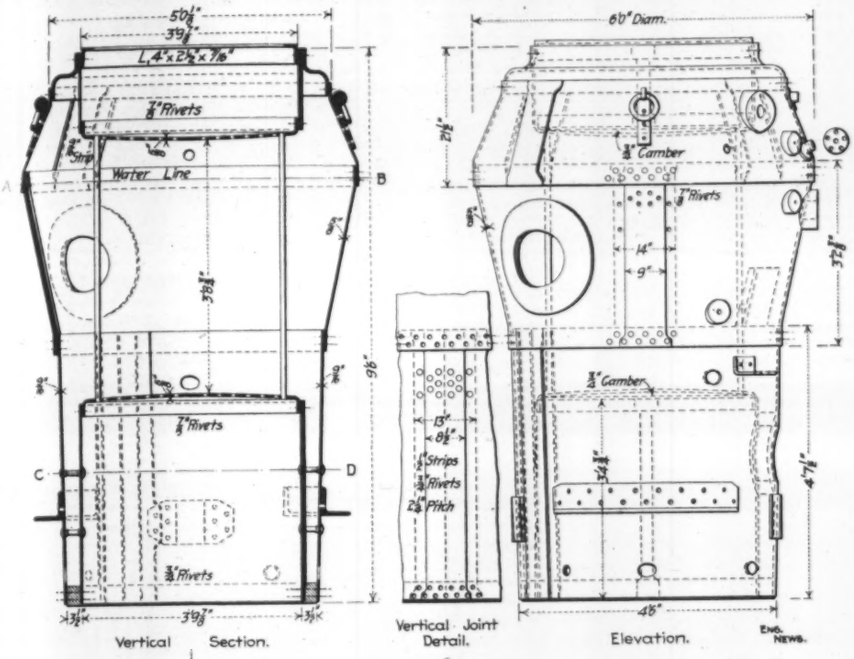
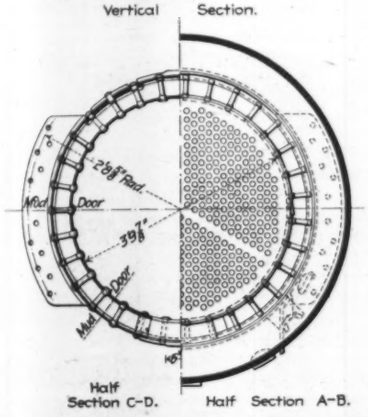


FIG. 5. VERTICAL BOILER FOR STEAM CAR; GREAT WESTERN RY., ENGLAND.



stations four of the cylinders may be stopped, leaving two cylinders running continuously to start the others on starting the car. For circulation in the cylinder jackets, 36 gallons of water are carried in three tanks, and the water returning from the jackets is cooled by passing through radiators under the car. This car is being built by Sir W. G. Armstrong, Whitworth & Co., for the Roots Oil Motor & Motor Car Co., of London, but Mr. H. A. Ivatt, Locomotive Superintendent of the railway, wrote us in April that it had not been delivered, nor did he know when it would be ready.

TAFF VALE RY.—A steam-car was put in service on this road towards the end of 1903, and the results were so satisfactory that six more cars were ordered. The first car was built by the railway to the designs of Mr. T. Hurry Riches, Locomotive Superintendent, and the others are being built by contract to the same designs: the cars by the Bristol Wagon & Carriage Works Co. and the engines by the Avonside Engine Works, of Bristol. The first car was run on all the heavy branches of the line, many of which have long grades of 2.5%, and it fully answered all expectations. It was then put in service between Cardiff, Penarth and Cadoxton, a distance of 9½ miles. It stops at stations and road crossings, and the fare is 2 cts. per mile. The maximum speed attained is 43 miles per hour, and a speed of 30 miles per hour can be reached in 35 seconds.

This steam car is 45 ft. long over the body, 58 ft. 9 ins. long over all, 8 ft. wide and 7 ft. 2½ ins. high from floor to roof. It carries 12 first-class and 40 second-class passengers (called "third-class"), as on the London & Southwestern Ry., already mentioned. The first and second-class compartments have longitudinal and transverse seats, respectively, with a central aisle. There is also a baggage compartment, next to the engine compartment. At the rear end is a platform 32 ins. wide, with entrance to the first-class compartment, and an open gangway of the same width between the two compartments (instead of between the passenger and baggage compartments, as in the other car), affords access to both.

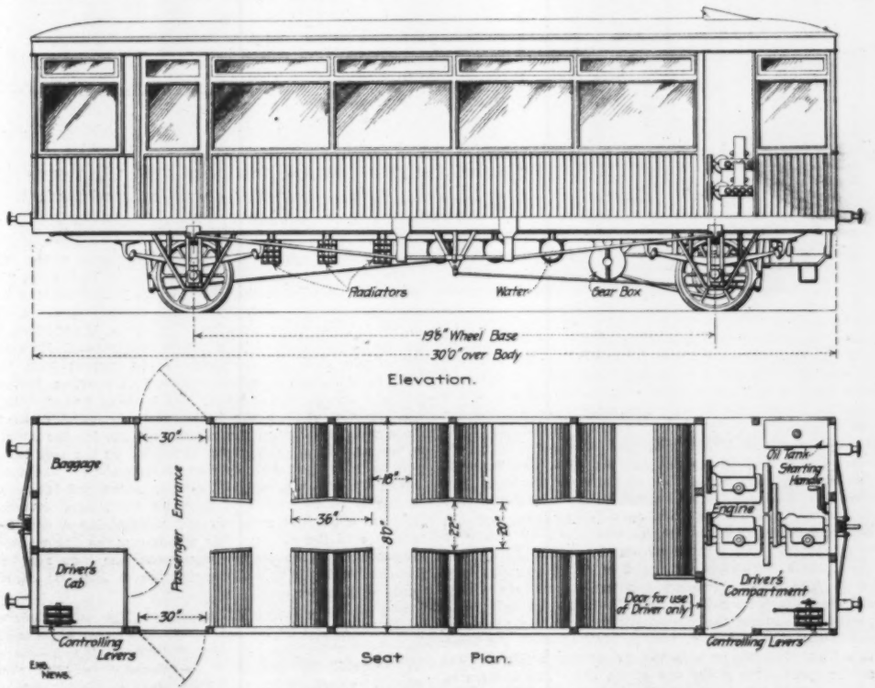


FIG. 6. OIL MOTOR CAR FOR THE GREAT NORTHERN RY., ENGLAND.
Roots Oil Motor & Motor Car Co., London, England, Builders.

The compartments are heated by steam on the Peters system. Steps can be lowered for use at crossings, but at stations (with high platforms level with the floor of the car) these are folded up, being operated by a lever. The underframe is of steel, and the car is mounted on two trucks with 34-in. wheels; (those of the rear truck having wood centers). The wheelbase is 8 ft. for the rear truck and 8 ft. 6 ins. for the driving truck, while the total wheelbase is 49 ft. 3½ ins. The weight of the machine in running order is 33 tons.

The boiler, placed at the head end, is of the horizontal tubular type, with steel shell and copper firebox. It has 312 tubes, 1¾ ins. diameter and carries a pressure of 160 lbs. The heating surface is 338.5 sq. ft. (tubes, 299.5 sq. ft.; firebox 39 sq. ft.); grate area, 8 sq. ft. The cylinders, 9 × 14 ins. are outside, between the axles, and drive the leading axle only, no coupling rods being used. The eccentrics are inside, and drive the slide valves on top of the cylinders by means of a link motion and rock shaft. The engine is fitted with a screw reversing gear, and has both steam and hand brakes. The tanks carry 530 gallons (English), and the bunker has capacity for 1,120 lbs. of coal. The tractive power is given as 4,263 lbs. at 80% of the boiler pressure. The car is run with either end in front, and when running with platform first the conductor stands on the platform, whence he can signal the engineman by an electric bell; he can also sound the whistle, shut off steam, and apply the hand brakes on the truck.

ALEXANDRA DOCKS & RAILWAY.—A steam car service is to be instituted on this line during the coming summer at the instance of Mr. John Macaulay, General Manager, in order to serve the existing needs of the towns of Caerphilly and Pontypridd, and the villages between them, and also to assist in developing the coal district around Caerphilly. It was his opinion that the provision of a cheap, convenient, and frequent train service would of itself tend to develop travel. The distance between the two towns is 7 miles, with one intermediate station, but the steam cars will make six intermediate stops at points where main roads cross the railway. The maximum grade is 0.5%. There are four regular trains daily stopping at the three stations, while the steam cars will make about 20 round trips daily, with average and maximum speeds of 15 and 25 miles, respectively. No baggage or freight is to be handled, with the exception of the light baggage carried by the passengers. The fares will be less than on the trains.

There will be two cars 54 ft. long, weighing 23 tons, and built by the Glasgow Engineering Co.,

of London. The passenger section accommodates 50 passengers, and at one end is the vertical boiler (with cross tubes) which carries 150 lbs. pressure. The car is mounted on two trucks, with 40-in. wheels for the leading (or driving) truck, and 33-in. wheels for the trailing truck. Each truck has a wheelbase of 8 ft., and the total wheelbase is 40 ft. The engine is rated at about 60 HP., and has a pair of outside cylinders 8 × 12 ins. Each car will carry an engineman and a conductor.

NORTHEASTERN RY.—This road has found the operation of its branch lines unsatisfactory, and has therefore experimented with the motor car system. Two of these were first tried on the line between the two towns of Hartlepool, but they were not successful, owing to mechanical defects. Other cars of the electric type were then built, and have proved satisfactory. One of these is shown in Fig. 7, and the following description is from a statement sent us by Mr. Wilson Worsdell, Chief Mechanical Engineer:

The car is mounted on trucks, and is 52 ft. over end sills, with an inside width of 7 ft. 11 ins. It is divided into three compartments; that at the forward end contains the petrol motor and generator, and between this and the passenger portion is a gangway to permit of entrance to either the engine or passenger compartments; the rear compartment contains the machinery for operating the car from that end. There are two rows of reversible seats, with central aisle, affording seating accommodation for 52 passengers. The car is lighted by incandescent lamps of 16 c. p., current for which is supplied from accumulators carried under the center of the car. It is heated for winter service by a series of radiators. The weight of the car in full working order is 35 gross tons.

The engine compartment is 13 ft. 3 ins. long, and contains an 80-HP. four-cylinder horizontal petrol motor, built by the Wolseley Tool & Motor Car Co., of Birmingham. The cylinders are 8½ × 10 ins., and the normal speed of running is 420 revolutions per minute, which can be accelerated to 480 revolutions per minute for starting the car quickly. The cylinders are overhung on a stiffly constructed cast iron crank chamber, the inspection covers being on the top, and the oil trough beneath. Forced lubrication is used for all the main bearings. The fly-wheel, which is truly balanced, is 3 ft. diameter. All the valves are mechanically operated by cams on the two camshafts, and these shafts are driven by means of spiral gearing and layshafts from the crank shaft. The crank shaft is "two-throw," and of Vickers-Maxim cast steel. The engine cylinders and valve boxes are water-cooled, a Clarkson radiator and Blackman fan being employed for cooling the circulation water. The engine is governed by the throttle, and in addition auxiliary hand throttling it fitted, so that the driver can accelerate the engine speed from either end of the car. The ignition is of the usual high tension system.

The engine is directly coupled to the generator, which is a separately excited, compound-wound, direct-current engine-type machine of 55 KW. capacity, specially designed for operating over a range of voltage from 300 to 550. This machine operates at a normal speed of 420 revolutions per minute, and is supported on an extended bed-plate; the armature being pressed onto the extended engine shaft provided with a flanged coupling between the generator and motor. The field for the generator is split horizontally, so that the upper half may be removed for access to the armature or field coils through an opening in the roof of the car, fitted with a removable cover. The exciter is a 375 KW. standard 72-volt shunt-wound belt-driven multipolar generator, mounted above the main generator and belted to a pulley on the extended shaft. This is capable of exciting the main generator and of supplying current for lighting incandescent lamps of 72 volts 16 c. p. The voltage of this machine may be increased to 95 volts for charging the battery when not required for lighting.

Two Westinghouse 35-HP. railway motors with single reduction gears, ratio 18 to 64, are mounted on the front truck by means of a nose suspension bar with spring attached to the truck frame. These motors are series-wound and are of the type usually employed for operating heavy high-speed electric cars. The controllers are the standard series-parallel street railway type arranged for electric braking. Resistances are provided in connection with the controllers for gradually increasing the voltage of motors in starting the trains, and for graduating the electric brake in stopping. These resistances are mounted beneath the car. The storage battery consists of 38 cells in ebonite jars, assembled in a wooden box suspended beneath the car. Each battery has a capacity of 120 ampere hours.

The electric brake equipment consists of two electric magnets suspended between the wheels of each truck and immediately above the track rail. It is so constructed that the magnetic circuit is completed through the track rail, so that when the coils are energised the magnet is attracted to the rail, thus causing friction between the magnet and the rail and retarding the motion of the car. This retarding action brings pressure to bear upon the brake shoe applied to the wheel, which further retards the motion of the car, and this friction of the magnet on the track and the brake shoes on the wheels is sufficient to bring the car to a stop in an extremely short distance. The brake coils are energised by the current from the motors operating as generators, and this action further absorbs energy and adds to the braking power. This feature also renders the brake perfectly reliable, as it does not depend upon the generator plant for the supply of power. An air compressor is located on the rear truck and supplies air for blowing an alarm whistle. The compressor is driven by a 1 HP. electric motor, and is started and stopped by means of pressure controlling switches and cut-outs, thus automatically maintaining a constant pressure in the air reservoir which supplies the whistle. The whole of the electric equipment has been supplied by the British Westinghouse Electric & Mfg. Co., Limited, of Manchester.

The system of working is as follows: The current passes from the generator through an automatic circuit breaker to the controllers, and the voltage of the generator is adjusted by means of a rheostat in the field circuit placed near the controller at each end of the car. The generator is used as a motor supplied with current from the storage battery for starting up the petrol motor. After having brought the engine and generator up to speed and the pressure has been adjusted to 400 volts, the car is started in the usual way by manipulating the handle of the series-parallel controller to the series point for slow speed and to the multiple point for high speed. Afterwards the voltage of the generator is gradually increased to 550 by manipulating the field rheostat near the controller. At this pressure the car will accelerate until a constant speed of 36 miles per hour is attained. In stopping the car, the controller handle is moved back to the "off" position and then in a reverse direction over the breaking points, thus applying the magnetic track brake. As soon as the car is brought to a standstill the generator field rheostat is re-adjusted to give 400 volts and it is then in a position for restarting. If it is desired to operate the car at half-speed, the voltage may be raised to 550 volts by adjustment of the rheostat with the controller handle on the full series point. From this it will be seen that a wide range of speed is obtainable by variation in the voltage of the generator at two points, viz.: approximately half speed and at full speed. These cars can be put into service at 10 minutes' notice, and they carry a supply of both fuel and water for a full day's work. They can be driven from either end with equal facility.

FRANCE.

NORTHERN RY.—This company has been working light or auxiliary trains for nearly 25 years, and has been working on the motor car problem since 1893, when it designed a storage battery car for 50 passengers, having the battery mounted on one of the trucks. In 1896, a smaller electric car was built for carrying mails and 12 passengers. In 1901, this was improved by substituting two motors, with flexible attachments, for the single motor. In 1897 a steam car with Serpollet boiler was put in service between Creil

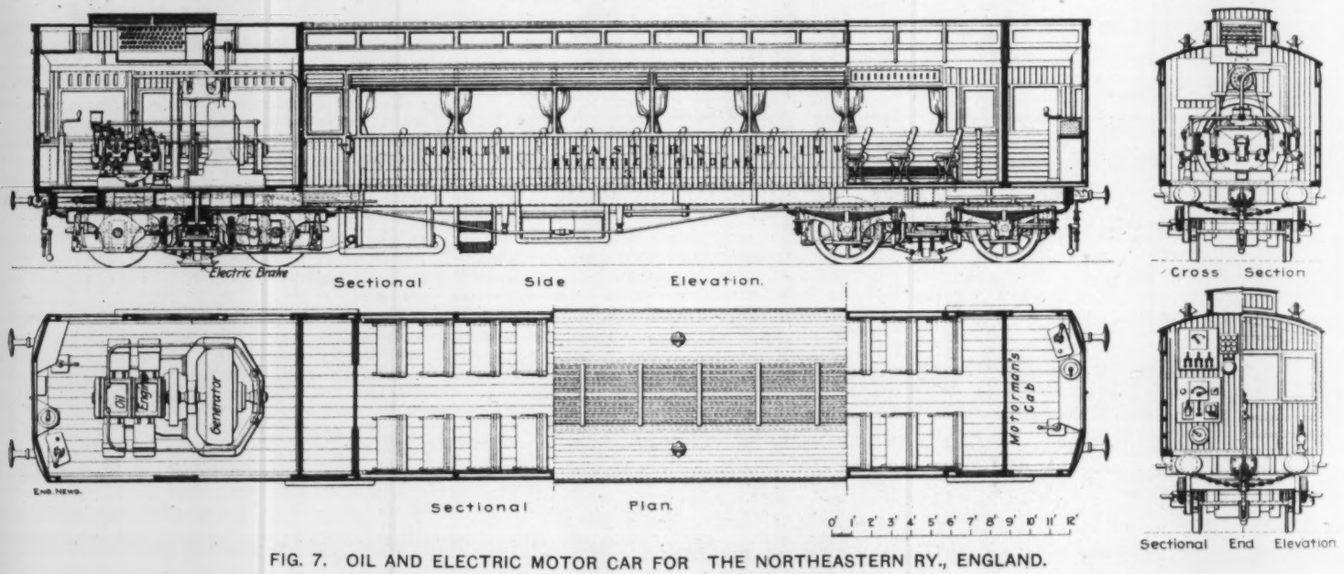


FIG. 7. OIL AND ELECTRIC MOTOR CAR FOR THE NORTHEASTERN RY., ENGLAND.
Wilson Worsdell, Locomotive Superintendent.

and Beauvais, and is still in operation, but with a Turgan boiler which was substituted for the Serpollet in 1900. This is a four-wheel car for carrying the mails, and was put in service specially to take the place of the early morning train, which seldom had passengers. The distance is 16¾ miles, with maximum grades of 0.4%. The steam car can haul two light passenger cars, and sometimes a milk car in addition, making a train load of 35 to 44 tons. The outward trip is made in 1 hr. 16 mins., with three stops; the return trip is made in 1 hr. 26 mins., with ten stops.

The car body of this steam car or "automobile postale" is carried on a frame of steel channels, while the engine and boiler are carried on independent plate frames inside of the channel frames to which they are attached. At the front end is a cab like the vestibule of a street car, and behind this is the boiler, which is very short, of the Turgan type, with smokestack at one side. Behind this, and occupying a little more than half the length of the machine is the mail compartment, entered by the side doors.

There are two axles, 8 ft. 4 ins. c. to c., with 37½-in. wheels. The cylinders are 7.08 × 9.84 ins., placed midway between the axles, and between the plate and channel frames. The connecting rods are attached to crank pins in the leading wheels, the driving gear and valve motion being similar to those of ordinary locomotive practice. The boiler has 184 sq. ft. of heat

ing surface, 7.17 sq. ft. of grate area, and has a working pressure of 225 lbs. The engine has the Westinghouse air brake on all wheels, and also a hand brake. It carries 1,100 lbs. of fuel and 1,[illegible] gallons of water, the latter being in a tank over the trailing axle. The weight is 30,356 lbs., of which 20,304 lbs. are on the driving axle.

haust steam. The cars are lighted by electricity from the storage batteries, and fitted with the Westinghouse brake.

The central or engine section is the most important feature of the machine. It is 27.71 ft. long, and is mounted on four wheels, with a wheelbase of 14.1 ft. The weight is 22½ tons

are placed outside, driving end cranks, with a counterweight on the axle between the crank and the frame. The crosshead has a sleeve sliding on a single guide bar of diamond section, and the connecting rod is 3.67 ft. long, c. to c. The valves are on top of the cylinders, and are driven by valve gear of the Walschaert type. Live steam

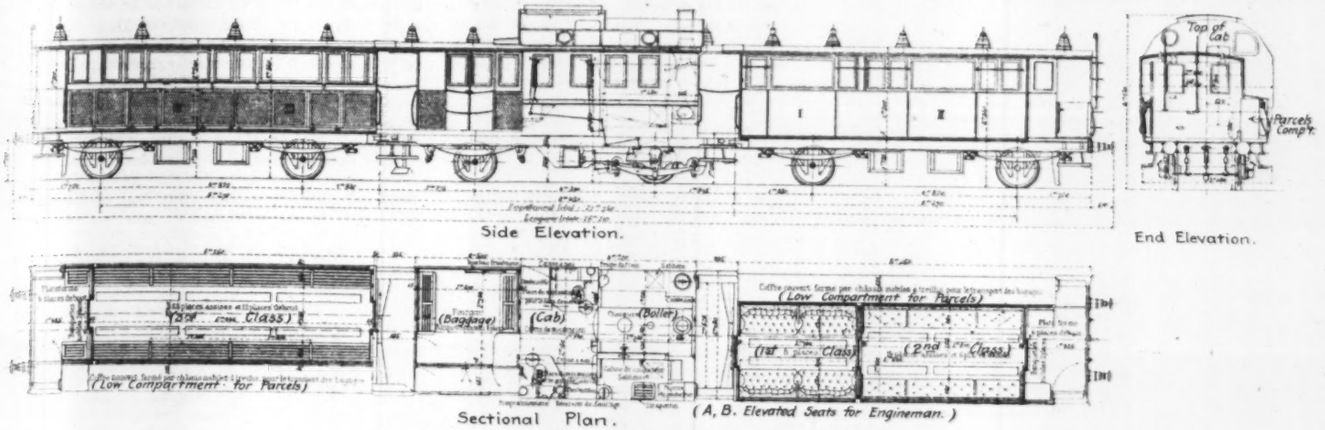


FIG. 8. STEAM CAR OF THE NORTHERN RY., OF FRANCE.
Mr. Du Bosquet, Chief Engineer of Traction and Rolling Stock.

A more elaborate steam car, intended for auxiliary service between regular trains at points on the main line, has been built to the designs of Mr. Du Bosquet, Chief of Traction and Rolling Stock. In the design of this car the following points were decided upon: 1, It must normally accommodate at least 50 passengers of the three classes, and have accommodation for additional passengers during busy times; 2, There must be provision for baggage, parcels and market baskets; 3, Entrance to the compartments should be by platform, no side doors being used; 4, The conductor must be able to go from end to end of the car; 5, The car must be operated by only two men, an engineman and a conductor; 6, The car must be capable of an average speed of 37 miles an hour, and of running 30 miles without taking water; 7, The car must be able to be operated in either direction. The car as built, and shown in Fig. 8, is practically a three-car train or "articulated car," each section being carried on four wheels. This articulated arrangement is used for the tramway-trains or auxiliary trains operated by this railway. Two cars have been built in the railway company's shops and are in operation in the Valenciennes local service. They have made 46½ miles per hour in tests.

The middle section contains the boiler and engine, a conductor's compartment, baggage compartment (for 1,200 lbs.) and an elevated cab for the engineman, who can thus see over the roof of the end sections. The cab has a seat on each side, so that the man may always be on the right side, whichever way the car is running. One of the end sections has two compartments for 8 first-class and 14 second-class passengers; the other end section has a compartment for 28 third-class passengers, giving a total seating capacity of 50 passengers. But in case of emergency 6 more can be accommodated on folding seats in the baggage department; two folding seats can be let down on each end platform, and 26 persons can stand inside and on the platform, making a total capacity of 86 passengers. In addition to the central baggage compartment there is along one side of each end section a low projecting compartment fitted with removable panels of open latticing and intended specially for the accommodation of packages. This is outside the car, and on the engineman's side, so that the side of the car is set back and he has a good view ahead. The total length is 86 ft., with a wheelbase of 71.34 ft. The total weight is 40 tons empty or 43 tons loaded, with 15½ tons available for adhesion. Each of the end sections is practically a four-wheel car 27.5 ft. long, with a wheelbase of 15.8 ft. All the wheels (except the single pair of driving wheels)are 3.13 ft. diameter, with a long plate spring over each axle box. Hot-water foot-warmers are set in the floor and heated by ex-

empty or 25 tons loaded, with 15½ tons on the driving axle. The single pair of driving wheels are 3.41 ft. diameter, and the others 3.13 ft. The frames consist of a pair of steel channels, outside the wheels, and to the inner face of each channel is riveted a deep ¾-in. plate extending about half the length of the frame. To this the cylinders and guide yoke are attached, and in it are

can be admitted to the low pressure cylinder when necessary, the gear being so adjusted as to give 10% greater admission to this cylinder, but the pressure is only 140 lbs. in the low-pressure as against 260 lbs. in the high pressure.

The reducing, Fig. 9, valve has three pistons on a horizontal stem, and in this figure it is shown in its two positions for working simple and compound. When working as a simple engine, steam is admitted to the high pressure cylinder by the passage A, and to the low pressure cylinder by the passage B, fed by a small opening in the valve, as shown. As the main valve is moved by

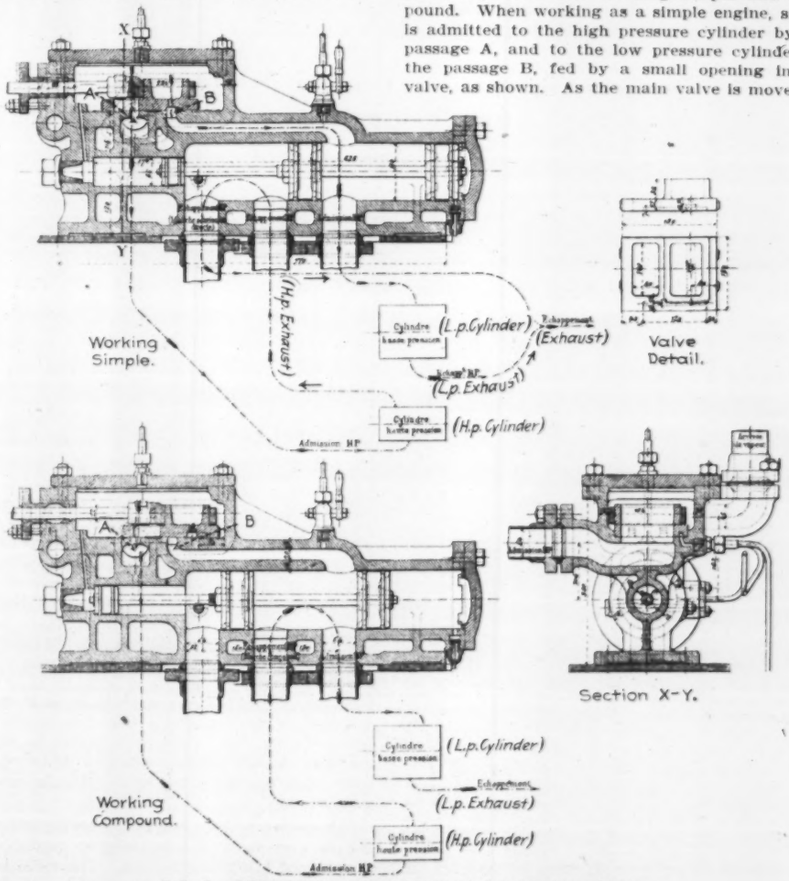


FIG. 9. REDUCING VALVE OF FRENCH STEAM CAR.

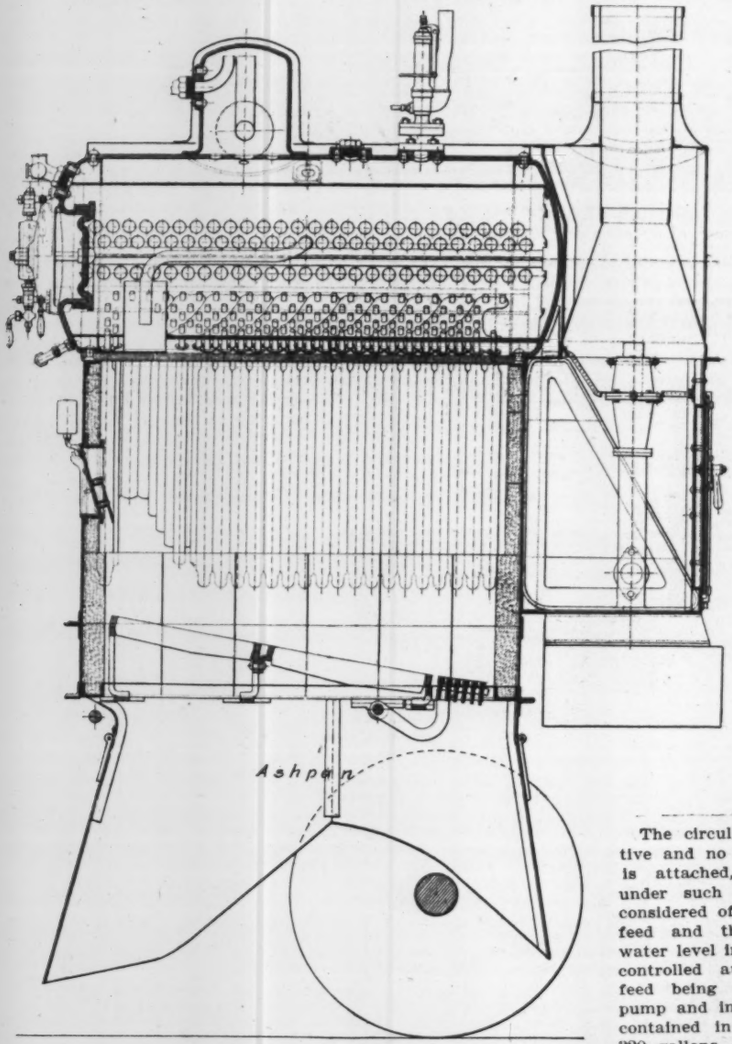
formed the pedestals for the driving box. Under each driving box is a long and heavy plate spring, with its ends attached by short links to the plate frame.

The engine is a two-cylinder compound, with cylinders 7.8 x 12.8 ins. and 10 x 12.8 ins. These

the engineman this passage B is closed, and a pipe on the outside (shown in the cross-section) admits steam at the right of the reducing valve, causing it to take the position for working simple.

The boiler, Fig. 10, is of the Turgan water-tube type, with inclined grate, and firebox large

enough to require replenishing only at stops, so that the engineman need give it no attention when the car is running. Rows of inclined tubes form the sides of the firebox, and connect with a top drum. The tubes nearest the firebox and smoke-box are 2.4 ins. diameter, and the intermediate tubes 1.6 ins. diameter. The drum has a 21-in. perforated inner shell and a 28-in. outer shell, 6 ft. 4 ins. long. Within each main tube is a ¾-in. tube extending into the interior shell. The main body of water passes down the larger tubes, where it is heated, and the mixture of steam and water rises through the inner tubes to the inner shell, from which it passes through the perforations to the outer shell. In this way an active circulation is maintained. The sides of the grate are of firebrick, and the outside shell of the firebox is formed of removable plates. Both an injector and a feed-water pump are used. The



Longitudinal Section.

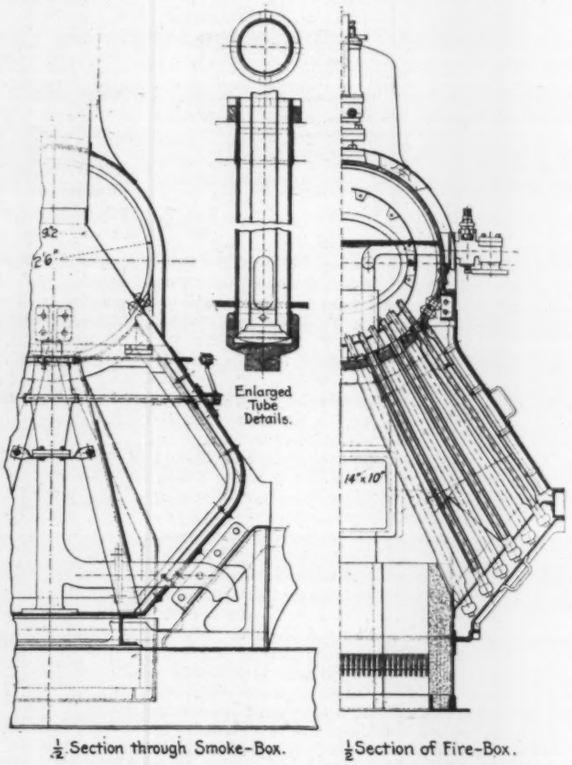
boiler is of comparatively light weight, and its particulars are as follows:

Tubes, No. 2.4-in., 86; 1.6-in., 174; total	260
Grate	4.77 × 2.23 ft.
Heating surface, direct	39.59 sq. ft.
" " indirect	279.76 " "
" " total	319.35 " "
Grate area	10.76 " "
Boiler pressure	200 lbs.
Water	695 gallons.
Coal	250 lbs.

PARIS, LYONS & MEDITERRANEAN RY.—This railway has two steam cars, built by Mr. M. V. Purrey, of Bordeaux. Each car is 36.6 ft. long, carried on four 36-in. wheels, with long plate springs over the boxes, and has a wheelbase of 19.2 ft. There is no baggage or mail compartment, as only hand baggage is allowed. There are two passenger compartments seating 12 "second-class" and 24 "third-class" passengers. Evidently the "first-class" passenger is not expected to avail himself of the humble motor car. The rear platform will accommodate 12 persons, standing.

The boiler is of the Purrey water-tube type, as used on some steam tramways; the firebox is surrounded by firebrick, above which are U-shaped tubes and coil tubes, their upper ends opening into a steam drum and the lower ends into a three-chamber reservoir. The feed water enters the lowest chamber, passes to the second by the U-tubes and then through a first system of coils to the third chamber. The steam is superheated in a second system of coils ending in the top drum.

Tubes, U, 24; inside diameter	0.68 in.
" length	5.2 ft.
WCoil tubes, 49; inside diameter	0.68 in.
" " length	22.0 ft.
Cube capacity	9.25 cu. ins.
Heating surface	280 sq. ft.
Grate surface	9 "
Pressure	400 lbs.



½ Section through Smoke-Box. ½ Section of Fire-Box.

FIG. 10. TURGAN WATER TUBE BOILER FOR STEAM CAR; NORTHERN RY. OF FRANCE.

The circulation is very active and no water level gage is attached, its indications under such conditions being considered of little value. The feed and the regulation of water level in the top drum is controlled automatically, the feed being by means of a pump and injector. Water is contained in a tank holding 320 gallons, placed under the rear platform. Coke is used for fuel and is placed in a bunker of 600 lbs. capacity. The bottom is inclined and is connected with the grate by a chute so that it is fed automatically. The engine has simply to regulate the draft by the ashpan dampers when running, and to shake the grate when the car stops at stations, etc.

The engine is a four-cylinder compound on the Purrey system, with two pairs of tandem cylinders placed inside the frames. The cylinders are 5.6 × 8 ins. and 8 × 8 ins. They drive a shaft from which power is transmitted to the axle by a chain and sprocket wheel gear. The valves of each pair of cylinders are operated from a single eccentric, which can be shifted to provide for reversing. All the special apparatus, pump, air compressor, etc., have been designed by the builders. The car is fitted with oil lamps, the Henry hand brake and the Westinghouse air brake. Its weight in working order is about 32,360 lbs.

The car is in service on the line from Alais to Ardoise, 36 miles, having an irregular profile and grades of 2% for several consecutive miles. Alone or with a 14-ton car attached it can ascend the 2% grades at 15½ to 25 miles an hour; it has also hauled two 14-ton cars, making the ascent at 12½ miles an hour, which is the speed allowed in the schedule. The car rides steadily at a maximum speed of 46 miles an hour. The fuel consumption varies from 10 to 15 lbs. per mile according to the load and speed. The evaporation is about 6 lbs. of water per lb. of coke.

This railway has also ordered two steam cars from the Gardner-Serpollet Co., having motors of the type used on automobiles, but of larger size and with power sufficient to run the car at 40 miles an hour on level track. Each car will have a motor compartment in front, a first-class compartment for 12 passengers (paying second-class fares), a third-class compartment for 29 passengers, and a rear platform on which 12 passengers may stand. There are two doors on each side.

PARIS & ORLEANS RY.—This railway has had a steam car built by Mr. M. V. Purrey, of Bordeaux, for use on the line between La Fleche and Sable. It is 45 ft. long over all, and is very similar to the car on the Paris, Lyons & Mediterranean Ry., already described, but is mounted on three axles, with wheels 3.44 ft. diameter and a wheelbase of 27 ft. The two end axles have lateral play in the boxes to facilitate the passage of curves. The first two axles are 10½ ft. apart, and have their pedestals connected by longitudinal members, while the inner ends of the long plate springs over the boxes of these axles are connected to an inverted plate spring equalizer seated under the sill. At the front is the engine and boiler compartment, with the end-shaped like a wedge or wind-cutter; next came a baggage compartment and a mail compartment. The passenger compartment has seats for 20 passengers, while the rear platform has seats for six more. The body is 42 ft. long, 10 ft. wide and 8 ft. 3 ins. high. The weight of the car in working order is 28 tons.

The engine and boiler are of the same type and

size as in the Purrey car already described. The car is heated by exhaust steam from the engine, and is fitted with the Westinghouse brake. The fares charged are the same as for second-class accommodation on the steam trains. Ordinarily the car hauls a 14-ton six-wheeled car seating 50 third-class passengers. The acceptance tests were made on the line from Bordeaux to Eymet, 65 miles, with maximum grades of 1.5%, some of these being two miles long. With the trail car attached, speeds of 37 to 46 miles an hour were obtained on the level, and the grades were ascended at 24 miles an hour. The fuel consumption was about 10 lbs. of coke per mile, with an evaporation of 6 lbs. of water per lb. of coke.

STATE RAILWAYS.—Two four-wheeled Purrey steam cars, very similar to that of the Paris, Lyons & Mediterranean Ry., already described, have been put in service on the line from Bordeaux to Saint Andre de Cubzac. Each car is 39.3 ft. long and 9 ft. wide, weighing 20 tons. It is divided into an engine compartment, baggage compartment, and two passenger compartments for 8 and 10 passengers, and a long rear platform for 12 persons standing. Exhaust steam heats the car by means of radiators, and electric current for lighting the car at night and in the tunnels is furnished by a dynamo on the rear axle. The cars are intended to haul one or two freight cars. They are designed for a speed of 55 miles an hour, and have engines rated at 100 HP.

DROME RY.—This small narrow gage line has in service a four-wheel car driven by a 10-HP. vertical inverted Turgan petroleum engine, with four cylinders, 4 × 4½ ins., making 800 to 1,000 revolutions per minute. The car is 25 ft. long, and 5 ft. 6 ins. wide, with a wheelbase of 6 ft. 4 ins., and wheels 3 ft. 4 ins. diameter. Its tanks carry 15 gallons of liquid fuel and 25 gallons of water for cooling the cylinder. The weight of the car is about 4¼ tons.

GERMANY.

BAVARIAN STATE RAILWAYS.—Storage battery cars have been in use for about seven years, in that part of Bavaria known as the Rhine Pfalz, the cars running as auxiliary to the regular steam trains, and also carrying workmen to and from their places of work. The longest run is about 27 miles. The cars are 60 ft. long, mounted on trucks; they weigh 45 tons and seat 106 passengers in two compartments with side doors. The batteries are rated at 70 HP., and supply current also for lighting the car. These cars were built in Baden, the electrical equipment being furnished by the Schuckert Electrical Co.

The U. S. Consul at Manheim, Mr. H. W. Harris, reported in March that the Department of Traffic of the Bavarian Government had requested several firms to submit bids for the delivery of motor cars to be used in connection with the present train service. For main lines the cars are to be of two sizes, the larger to have a seating capacity for 60 passengers and standing room for 20 more. The cars are to have a compartment for baggage and to be capable of seating 40 persons and furnish standing room for 20 additional persons. This class of cars with one trailer must be capable of carrying a gross weight of 20 tons.

The motor cars for branch and local lines are to be similar in form to those specified for main lines, but to be of less capacity. They are to be of two types: one, to be fitted for passengers, freight, and mail service; the other for passengers and baggage, with provision for a small amount of mail. The cars of each type are to provide for first, second and third-class passengers, with smoking compartments and ample facilities for heating and lighting. The speed attainable by the cars without trailers is to be, on the main lines, 45 miles per hour. The smaller cars designed for main lines are to have a speed of 36 miles per hour. The maximum speed of the cars for use on branch or local lines will be 30 miles per hour. The other general features of the cars, including the kind of power to be used, the number of axles, the arrangement of doors, etc., is left to the bidders.

WURTEMBURG STATE RAILWAYS.—With the idea of providing a service auxiliary to that of the regular trains the administration of these railways commenced experiments in 1893 with a motor car operated by a Daimler oil engine. Several improvements have been made from time to time. The latest motor cars, Fig. 11, seat 44 passengers and are carried on two axles, with a wheelbase of 15 ft. 9 ins. and wheels of 3 ft. 3½ ins. diameter. The underframe consists of two steel channels 3 ft. 4 ins. apart, with two transverse frames the full width of the body, 10 ft. These cross frames are between the axles. Double elliptic springs are placed at each end of the sills and cross frames ,and on these eight springs rests the body.

The engine is mounted at the middle of the car, and drives, through the medium of a gear box, a set of miter gear with two wheels on a countershaft carrying the pinion which meshes with the bevel spur wheel on one of the axles. This miter gear allows of driving the axle in either direction, and the car can be controlled from either end. A 30-HP. vertical inverted Daimler engine is used, with four cylinders 5¼ × 7 ins., making 600 to 800 revolutions per minute. The exhaust pipe is carried to the roof. The cranks are set at 180°. The change gear allows of four speeds 7½, 13, 23 and 36 miles per hour. Water circulation in the jackets is maintained by a pump. The car weighs 12½ tons empty, and carries enough oil for a run of 200 miles. The cost of maintenance is said to be very light.

The car has end doors opening onto vestibuled platforms, and there are transverse seats. At the middle, however, where the top of the engine is enclosed in a housing, there are side seats, so as to allow room for passage by the engine casing. Five cars of this kind have been in service for four years, and are said to have averaged 30,000 miles each in that time. The cars cost about $5,500, and the cost of operation is about 5 cts. per car mile, including oil, lubrication and wages of two men.

OTHER COUNTRIES.

In all the recent descriptions of motor car service on railways very little has been said about Belgium, probably for the reason that nothing new has been developed there, and the system introduced by Mr. Belpaire on the Belgian State Railways nearly thirty years ago is still in operation. Some of the Belpaire steam cars are 46 ft. long, weigh 50 tons, carry 50 to 55 passengers, and run at speeds of 18 to 34 miles an hour, being operated by either two or three men. Oil motor cars of the Daimler system are in use in Switzerland and Hungary and on the Austrian State Rys. and Saxony State Rys. The Mediterranean Ry., of Italy, is using some steam cars. In Russia, the Nicholas Ry. has two steam cars, using naphtha fuel; these have a maximum speed of 14 miles an hour, are operated by three men to each car, and carry 20 first-class, 20 second-class and 40 third-class passengers. Of course the railways mentioned in this article are not the only ones using the motor-car system; there are many others whose work has not been made public.

It is of interest to note here that the Government of India recently invited bids for a steam motor car for a railway of 5 ft. 6 ins. gage. The car was specified to be 57 ft. long, with steel underframe, and mounted on a pair of trucks. It was also required to accommodate 3 first-class passengers, 3 second-class, and 72 third-class, together with baggage, fuel and water, and to be capable of traveling at a speed of 30 miles an hour for a 30-mile run on level track.

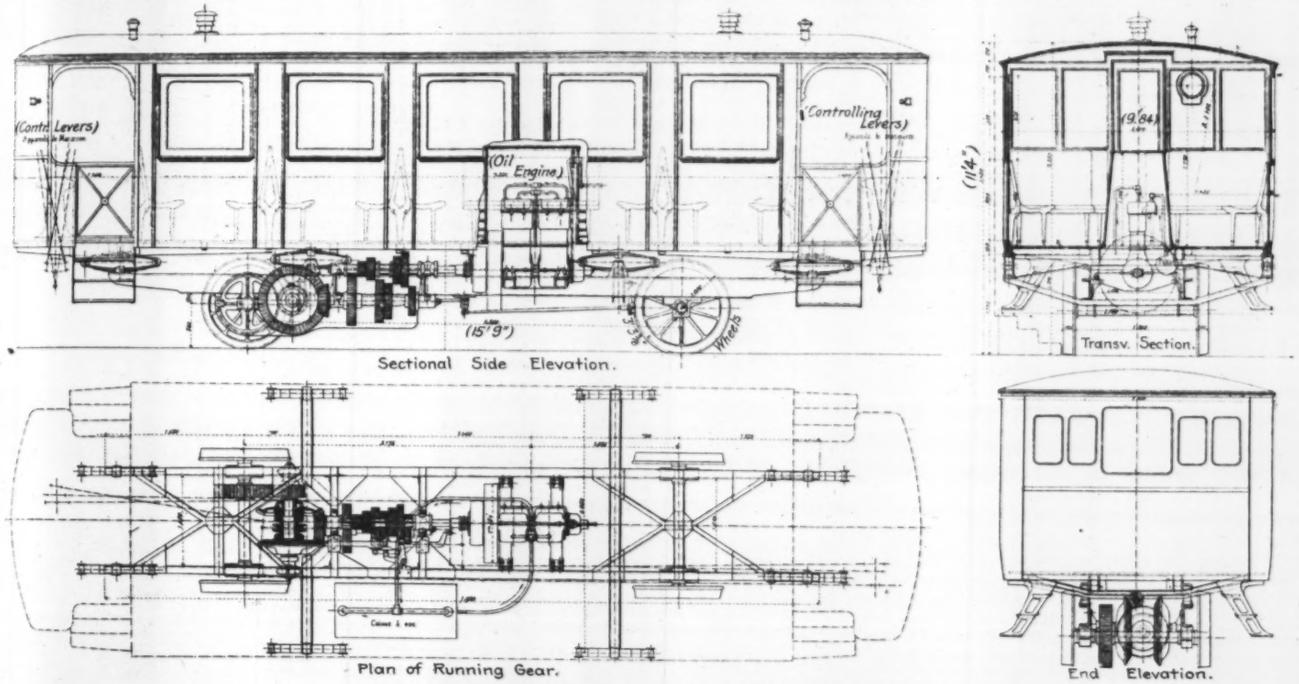


FIG. 11. OIL MOTOR CAR OF THE WURTEMBEFG STATE RAILWAYS.

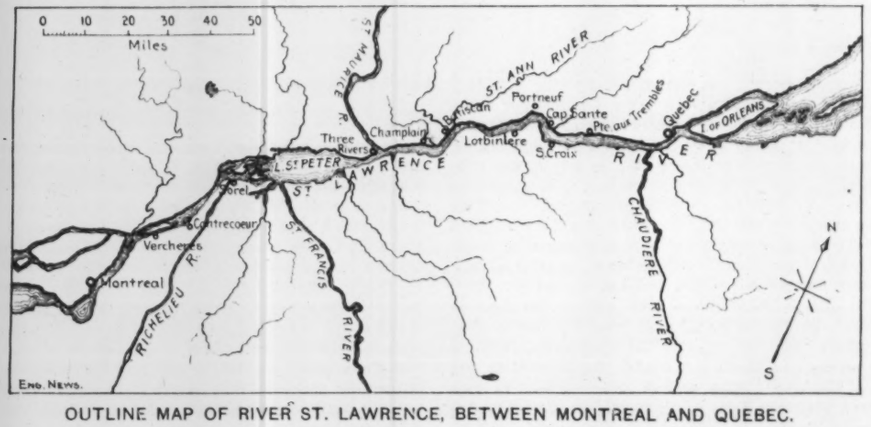
ROAD MOTOR CARS.

In addition to the introduction of motor cars running on the tracks, some English railways have instituted a service of motor cars on the public roads, giving direct communication between villages or places of interest and the nearest railway station. One of the most notable cases of this kind is the service instituted by the Great Western Ry. between Helston station and Lizard Point, in Cornwall. These are open cars with a canopy, and have long side seats and one cross seat behind the driver, seating 22 passengers in all. They were built by the Milnes-Daimler Co., and each has a 16-HP. oil engine, with Sims-Bosch magnetic ignition and automatic admission valve governed by the throttle. There are four rates of speed, with 4 and 12 miles per hour as the minimum and maximum. Good braking power is applied, and there are tire brakes for emergency. The car weighs two tons and carries 14 gallons of oil, sufficient for 140 miles. The cost was about $4,000 per car. The cars make six trips per day, connecting with five trains which stop at Helston. The Northeastern Ry. has a similar service, the cars carrying 16 passengers and 1,000 lbs. of baggage, and averaging about 12 miles an hour on the road. The route is from Beverley to Beeford, serving five or six intermediate villages. Four trips each way are made daily. The Great Eastern Ry. also intends to operate a motor car service this summer on the public road between Lowestoft and Southwold, the railway having a station at the former town, and both being seaside summer resorts. In Ireland, the Belfast & County Down Ry. has established a freight service with a traction engine and wagons, serving districts tributary to but not directly reached by the railways.

Very few experiments of this kind have been made by the continental railways, but it is stated that the Department of Traffic of the Bavarian government has invited bids for motor cars suitable for street and country highway service in connection with the railway and postal systems. The cars are to include omnibuses for carrying passengers, and wagons for the delivery of freight and express matter to and from the railway lines. They are to be operated for considerable distances.

THE IMPROVEMENT OF THE ST. LAWRENCE RIVER SHIP CHANNEL.

The so-called St. Lawrence ship channel comprises that portion of the St. Lawrence River lying between the cities of Montreal and Quebec. The total length of the water way between the two cities is 160 miles, of which the natural channel, not requiring improvement, covers 97½ miles, whilst there are 62½ miles of improved channel. There is no tide for the 82 miles between Montreal and Three Rivers; the fall of the river between the two places is 11 feet. From Three Rivers to Batiscan, 20 miles, the tide can always be felt, but owing to uncertainty of time and height, it cannot be depended upon for navigation. The fall for this portion of the river is 3½ ft.



OUTLINE MAP OF RIVER ST. LAWRENCE, BETWEEN MONTREAL AND QUEBEC.

Over the 22 miles from Batiscan to Portneuf, during 6 hours out of every 12, half-tide giving an additional depth of from 1½ to 4 ft., may be taken advantage of by passing during that six hours. The fall on this stretch is 10½ ft. In the 36 miles from Portneuf to Quebec there is a tide of from 9 to 15 ft., giving a tidal navigation for about 9 hours out of every 12. The fall is 4 ft., making the total fall in water level in the river at ordinary low water, between Montreal and Quebec about 29 ft. The current varies throughout. It is strongest at St. Mary's Current in Montreal Harbor, at Cap à la Roche and at the Richelieu Rapids. It is quite gentle in Lake St. Peter. The general average is about 2½ miles per hour. The water in the river has a very great annual fluctuation. The average height above ordinary low water ranges from 6½ ft. in May to ¾ ft. in November. Before the commencement of any dredging operations, the depth on the flats of Lake St. Peter was about 11 ft. at the ordinary autumn low water of that time. The actual improvements were commenced in 1844, and continued by the government as a public work until 1846, and abandoned the following year owing to opposition to the location of the channel.

From 1851 to 1888 all operations for the improvement of the St. Lawrence between Montreal and Quebec were carried on by the Montreal Harbor Commissioners, this body being placed in charge of the work in pursuance of legislative enactment passed in 1850. The interest on the cost of the work was defrayed by a tonnage tax on all vessels drawing 10 ft. and upwards.

In 1888 the channel from Montreal to Cap à la Roche was completed to 27½ ft. at ordinary low water, and from that point to Quebec to 27½ ft. at half tide. In this same year the work again passed to the control of the Department of Public Works, and continued under its direction. Between the years of 1888 and 1898, much work was accomplished, including the difficult rock work at Cap à la Roche and Cap Charles. Dredged portions of the river were cleaned up or deepened, and many curves and narrow places were widened. However, the extraordinary low water of 1895 and 1897, and the increase in the size of vessels, urgently called for a wider and deeper channel.

In the latter year it was decided to construct new plant consisting of large and powerful dredges, tugs, barges, etc., suitable for channel improvement on a large scale. In 1899 the dredging plant was in a position to warrant the commencement of a more extensive plan of operations. With a proper dredging fleet assured, and the necessary shops and ship yard at Sorel available, the work of making the 30-ft. channel was undertaken, the low water of 1897 being adopted as the plane or river level. The present object of the dredging operations is to obtain in the shortest possible time a ship channel between Montreal and Quebec for safe 30-ft. navigation. The minimum width for the tangents has been fixed at 450 ft., but the curves are widened to from 500 to 750 ft.

In the month of October, 1903, the dredging in Division 1 having been practically completed, and the work thoroughly tested, the department of Marine and Fisheries promptly erected the necessary light-houses and placed gas buoys to mark

Summary of Work Done by the Department of Public Works of Canada in Dredging the River St. Lawrence Ship Channel Between Montreal and Quebec in the Fiscal Year Ending June 30, 1903.

Dredge.	Kind.	Dimensions, feet: Over all length	Beam.	Hold depth.	Average draft.	Greatest working depth.	When built.	Working capacity per day, cu. yds.	Locality of dredging.*	Time of service, days.	Normal working time 20 hrs. per day.	Hours actual dredging.	No. of scows filled.	Number of cubic yards dredged, scow measurement.	Classification of Disbursements. 1 Fuel.	2 Wages.	3 Board.	4 Stores and materials.	5 Repairs, labor.	6 Proportion of General Landoffice expenses, etc.	Expenditure for each dredge.	7 Stone litter service, ice, elevator dredges.	8 Tug service.	9 Inspection, towing, etc.	10 Total cost of operations of each dredge and plant.	Average cost per cu. yd. for each dredge, cents.	Kind of material dredged.†
Lady Aberdeen	Elevator	148	32	13	7.5	42.5	1900	4,000	(1)	192	3,690	2,736¼	.....	982,750	$4,262.00	$6,040.01	$2,505.41	$1,247.63	$5,196.46	$1,572.16	$20,832.67	$197.30	$8,504.85	$2,752.41	$32,287.23	3.28	(8)
Lady Minto	Elevator	148	32	13	7.5	42.5	1900	5,000	(2)	190	3,645	2,615½	3,217¾	643,000	4,135.25	5,992.49	2,306.25	1,178.00	3,577.90	1,403.14	18,593.03	197.30	9,109.74	2,752.41	30,052.48	4.76	(9)
Laurier	Elevator	168	32	14	11	42.5	1897	2,000	(3)	172	3,305	1,989⅜	1,778	365,630	4,420.75	5,945.04	2,121.48	1,288.58	5,784.30	1,596.83	21,156.78	197.30	7,764.70	2,752.41	31,861.19	8.71	(10)
Laval	Elevator	150	30	14	11	43.5	1894	3,000	(4)	155	2,972	2,050	1,717⅓	273,425	4,292.50	5,499.02	1,995.10	1,319.50	13,435.28	2,166.09	28,707.49	197.30	5,985.42	2,752.41	37,342.62	13.65	(11)
Lafontaine	Elevator	168	32	14	9	45	1901	5,000 6,000	(5)	196	3,780	2,392½	3,875	1,162,500	5,495.25	6,214.13	2,455.69	1,675.07	4,850.23	1,088.88	22,370.25	197.31	8,174.74	2,752.41	33,503.71	2.88	(12)
Baldwin	Elevator	165	34	14	8	45	1902	2,500 3,500	(6)	191	3,528	2,670¼	2,702½	783,500	5,172.25	5,906.13	2 393.02	875.50	5,537.20	1,623.06	21,507.16	197.31	7,825.93	2,752.41	32,282.81	4.12	(13)
J. Israel Tarte	Hydr'lic	160	42	12.5	6	50	1902	20,000	(7)	....	.....	.....	.....	2,333,200	13,591.50	8,329.39	2,691.95	1,464.31	8,092.17	2,835.63	37,574.95	.....	14,796.73	5,504.83	57,846.51	2.48	(14)
Totals														6,544,605	$41,369.50	$43,935.21	$16,468.90	$9,048.59	$47,043.54	$12,885.59	$170,751.33	$1,183.82	$61,822.11	$22,019.29	$255,776.55	3.90	

* (1)—Centre Coeur.—Centre Coeur Bend, St. Ours Bend, Petit Traverse. (2)—Centre Coeur.—Petit Traverse, Centre Coeur Traverse. (3)—Pointe Aux Trembles (en haut). (4)—Pointe Aux Trembles, Pointe Citroille, Champlain. (5)—Centre Coeur.—Centre Coeur Course, Centre Coeur Bend, Upper half Bellmouth Curve. (6)—Petit Traverse, Pointe Aux Trembles (en haut). (7)—Lake St. Peter, Whitehall No. 2 Curve, No. 2 Curve.

† (8)—Blue clay, clay and stones, stiff blue clay. (9)—Stiff blue clay, blue clay and stone. (10)—clay and stones. (11)—Clay and stones, sand. (12)—Blue clay. (13)—Clay and stones. (14)—Stiff blue clay.

Classification of Disbursements in Percentage.

Dredge.	1	2	3	4	5	6	7	8	9	10
Lady Aberdeen...	.13	.19	.08	.04	.16	.05	.01	.26	.08	1.00
Lady Minto.....	.13	.19	.08	.04	.12	.04	.01	.30	.09	1.00
Laurier.....	.14	.19	.08	.04	.18	.05	.01	.25	.08	1.00
Laval.....	.11	.15	.05	.03	.36	.06	.01	.15	.08	1.00
Lafontaine.....	.17	.19	.07	.05	.14	.05	.01	.24	.08	1.00
Baldwin.....	.16	.18	.08	.03	.17	.05	.01	.24	.08	1.00
Israel Tarte...	.23	.15	.05	.03	.15	.05	..	.25	.09	1.00
Totals.....	.16	.17	.06	.04	.18	.05	.01	.24	.09	1.00

the bends and narrow places. The utility of the work done on the River St. Lawrence is evident. Advantage of every improvement is immediately taken, and at the present time several very large ships are being built with a view to the expected increased accommodation.

In the River St. Lawrence ship channel proper there were during the season of 1903 eight accidents to ocean-going ships. None were of a serious character, further than the delay and cost due to refloating the vessel and none were in any way due to inadequacy of the channel.

During the season of 1903 the total number of ocean-going vessels passing up and down was 802, an increase of 45 over the previous year. The total tonnage amounted to nearly 1,900,000 tons, about 350,000 tons greater than any previous year. This means an average of nearly 10 ocean-going vessels per day passing in one direction or the other through the ship channel. The River St. Lawrence between Quebec and Montreal is usually free from ice about April 10, and closed to traffic about Nov. 25, making the season of navigation about 7½ months.

The present available dredging plant consists of six elevator dredges, one hydraulic dredge, six tugs, and two staff and sweeping steamers. There is also a stone lifter, three coal barges, and the scow and the testing scow.

The elevator dredge "Laval" and "Laurier," are wooden vessels of 150 and 168 ft. in length, respectively. The "Lady Aberdeen" and "Lady Minto" are two vessels of similar type, built of steel and having a length of 148 ft. Two new wooden dredges, the "Lafontaine" and "Baldwin," have lengths of 168 and 165 ft., respectively. It is claimed that the "Lafontaine" has excavated the greatest quantity ever excavated by an elevator dredge in one year, viz., 1,162,500 cu. yds. The material was compact blue clay. The cost, 2.88 cts., is also a record. The hydraulic dredge "J. Israel Tarte" is built of steel and has a length of 160 ft.

All those dredges were built by and under the immediate control of the department, the "Laval" and "J. Israel Tarte" having been built by contract, and the five others having been constructed at the government shipyards at Sorel.

During the fiscal year ending June 30, 1903, the fleet of dredges removed a total quantity of 6,544,605 cu. yds., at an aggregate cost of $255,776.55, or at an average rate per cubic yard of 3.9 cts.

During the month of September, 1903, the hydraulic dredge, or "J. Israel Tarte," easily made the world's record for one month's dredging. In 25 working days the dredge was in actual operation 83% of the full working time of 132 hours per week, and removed 750,100 cu. yds., scow measurement. These results were calculated from actual measured cross sections, and by adding to the quantity in situ 25%, to make scow measurement. This makes over 30,000 cu. yds. per working day, or 1,650 yds. per hour of actual work.

Elsewhere in this issue the dredge "J. Israel Tarte" is described in considerable detail, and the methods of operating it are given.

Since the improvement of the lower St. Lawrence by dredging was begun, in the '40's to June 30, 1903, the total quantity of material excavated has amounted to 36,654,600 cu. yds., at a grand total expenditure of $4,910,155.62.

The accompanying table shows in detail the classification of the disbursements for the seven dredges in commission during the fiscal year ending June 30, 1903.

Another table shows the various items arranged by percentages, which shows that the largest single item is the tug service. Repairs, wages and fuel follow in the order named. The above figures are abstracted from the official report of the Minister of Public Works.

Progress of Dredging Operations on St. Lawrence Ship Channel to the close of the season of 1903.

Locality.	Total length requiring dredging Miles.	Length dredged in 1903 Miles.	Total length of 30 feet channel dredged Miles.	Length yet to be dredged. Miles.
Division 1: Montreal Harbor to Sorel.....	21.80	4.20	21.80	††
Division 2: Sorel to Batiscan....	12.45	1.20	4.90	7.55
Division 3: Lake St. Peter.....	18.00	3.50	{*7.20 {†2.39	8.50
Division 4: Batiscan to Quebec..	10.00	....	0.90	9.10
Totals.....	62.25	8.90	37.10	25.15

*Not widened. †Widened.
††Some cleaning up and banks to be straightened.

THE HYDRAULIC DREDGE "J. ISRAEL TARTE."*

By A. W. Robinson, M. Can. Soc. C. E.†

This dredge was placed in service in June, 1902, in deepening the channel through Lake St. Peter in the River St. Lawrence. As it involves some new features both in design and mode of operation, and has achieved a remarkable result, a detailed account of the dredge and of the work on which it is engaged will be of interest.

The Lake St. Peter Channel is part of the improvement in navigation of the River St. Lawrence between Montreal and Quebec. This work has for its aim the passage of ocean vessels to Montreal, making that city the point of trans-shipment of the inland lake and rail traffic by the St. Lawrence route to the sea. This section of the river is 160 miles long between the cities named, of which about 60 miles is dredged channel in about 20 different places.

The kind of material met with, varies in the different localities from soft clay to slate rock and stones. The dredging machines therefore, must be different in their character for the different sections of the work.

The original least depth of water in the channel was 10 ft., this being the nearly uniform depth on the flats of Lake St. Peter, which is a shallow expansion of the river about 9 miles wide by 18 miles long. The bottom here is of blue clay of a varying degree of softness, with some sand and stones in places.

For the information of those unfamiliar with the subject, the following table of the successive stages of water attained, and the dates of completion, is appended.

	Feet.
Original depth of water in channel	10
Dredging commenced in 1832.	
Depth completed in 1853	16
Depth completed in 1858	18
Depth completed in 1865	20
Depth completed in 1878	22
Depth completed in 1882	25
Depth completed in 1888 .....27½	
Depth now nearly completed	30

The fact that this great work was commenced in 1832 and prosecuted with more or less continuity ever since, is eloquent testimony alike to the importance of the work and to the energy, pluck and perseverance of those early pioneers who so boldly faced a work of such stupendous magnitude with the primitive appliances and slender financial resources which they then possessed. It is indeed a fortunate fact that all this early work still remains to the good, and that the character of this noble river is such that its bed is practically unchangeable. In this respect it is unlike the alluvial Mississippi, which requires a fleet of ten powerful dredges to maintain the channel. It is strange that in the public mind, unacquainted with the facts, there exists a widespread impression that much of this dredging is of a temporary nature and that it must naturally fill in again. This is entirely erroneous. The geological formation is such that there is practically no erosion of the banks, and the bed of the river is composed of various kinds of material, some of which is very difficult to dredge, and all of which (with the exception of one or two unimportant places where sand occurs) remains in place. Surveys and soundings made 60 years ago correspond closely with those of the present day. The work, therefore, is permanent.

The size of ships using the St. Lawrence route has steadily increased and has at times been fully up to the limit of the depth of water. In a paper on "The Economy of Large Ships," read by the author before the Society in 1902, he pointed out that when the 30-ft. channel of the St. Lawrence was completed, it could be navigated by a vessel 520 ft. long, 61 ft. beam and 12,000 tons dead weight carrying capacity (or about 20,000 tons displacement), and that the economy of such a vessel was nearly double that of a vessel of 5,000 tons capacity. It follows that a larger vessel would be still more economical, the limitations being only depth of channels, capacity of harbors and facilities for furnishing and handling large cargoes.

The condition of the St. Lawrence ship-channel, in 1901, was that the much-to-be-desired 30-ft. stage of water was still some distance off. There remained some 25 millions of cubic yards to be dredged, and the fleet of six large dredges were removing it at the rate of about 2½ million yards per season. In order to meet the demands of commerce and to complete the 30-ft. stage as early as possible, it was evident that something must be done to hasten the work. A large part of the balance remaining to be done lay in the soft clay of Lake St. Peter.

The existing channel through the lake was 300 ft. wide in the straight portion, and 27½ ft. deep (or 26.1 at new datum of extreme low water)* and about 18 miles long. The immediate work to be done was deepening to 30 ft. and widening to 450 ft. To allow a little margin the actual cut taken out in the deepening was about 5 ft., and the thickness of cut in the widening was 18 ft. to 20 ft. In the bends the width increases to 700 ft. The total volume to be removed to accomplish the deepening and widening in Lake St. Peter alone, was, therefore, in the neighborhood of 15,000,000 cu. yds. To remove this at a much more rapid rate than was heretofore possible, the then Minister of Public Works, the Hon. J. Israel Tarte, after investigating the subject, resolved on the adoption of the hydraulic type of dredge, and the writer was commissioned to design a dredge that would have a working rate of 2,000 cu. yds. per hour. These instructions were given in February, 1901, and it was desired, if possible, that the dredge should be in operation by the end of August of the same year.

The conditions which presented themselves were as follows:

A channel 26 ft. deep at low water, about 300 ft. wide in straight part and 600 ft. in the bends, and 18 miles long, with 10 ft. to 12 ft. of water on the banks. The section to be removed was that due to deepening the present cut 5 ft. and widening it 150 ft., and material blue clay of a varying degree of softness with some sand and stones in places.

The dredge, therefore, must fulfil the following conditions:

1. It must be able to make a cut 700 ft. wide at one time and 5 ft. to 10 ft. thick at one cut.

2. It must leave a clean and level bottom and cut mechanically the entire area, as the material is blue clay and will not run or wash like sand.

3. It must deliver the material sufficiently far to one side of the channel to avoid any risk of washing back again.

4. The floating pipe-line must be so arranged that it will freely permit of the movements of the dredge, and that it will withstand the winds and waves due to the locality, and which are severe at times.

5. The dredge must be so worked that it will not obstruct the channel for passing ships.

6. The anchorage and movements of the dredge must be so arranged that the feed will be continuous and uniform.

7. The capacity to be a working rate of 2,000 cu. yds. per hour.

8. The dredge must have ample coal supply and provision for a double crew.

The dredge "J. Israel Tarte" was designed to fulfil the above requirements and was built by the Polson Iron Works, of Toronto, Ont., and delivered and tested in October, 1901. The contract price was $163,800. This price did not include the discharge-pipe nor winches, which at the time the contract was placed were not designed. In point of fact, when the contract was placed, nothing of the detail shop drawings of the dredge were made, nor any patterns available. In order to save time the contract was based on a general specification and outline design, leaving the details to be supplied afterwards as the work progressed. All drawings and patterns of every detail of the dredge were specially prepared and all material specially ordered, and the time which elapsed between commencement of the drawings and patterns and the testing of the dredge under steam was eight months.

Before describing the new dredge, brief reference will be made to the existing fleet of dredges and a statement given of the record already established by them on Lake St. Peter.

The fleet of dredges previously existing and engaged on the ship-channel between Montreal and Quebec comprises six elevator dredges, which, taking hard and soft material together, took out 2,479,385 cu. yds. in the fiscal year ending June 30, 1901, at a total cost of $128,259.17, or an average of 5.1 cts. per cu. yd.

These dredges have been brought to a high state of efficiency, and are the improved development of the early dredges on the work, the first of which was imported from Scotland in 1832.

The work done on Lake St. Peter by the elevator dredges may be illustrated by the "Aberdeen." Its buckets have a capacity of 1 cu. yd. each, and can work to a depth of 40 ft. Small wooden barges, holding 300 cu. yds. each, are used to take away the spoil, and one tug suf-

*This work to 1897 was done to ordinary low water datum. Since that date a new datum 1.4 ft. lower has been established, which corresponds to extreme low water a stage that has only once been reached in many years. The new channel of 30 ft. is therefore 3.9—or say 4 ft.—deeper than the 27½ ft. channel. In all ordinary seasons and except for a few weeks in the fall of the year the depth of water is 2 to 5 ft. above low water, so that a vessel of 30 ft. actual draft can safely navigate the 30-ft. channel except for a few weeks in the fall of the year, if the season should be a dry one.

*A paper read before the Canadian Society of Civil Engineers.

†14 Phillips Square, Montreal, Canada.

fices to do the work, going out with one barge while the other is being filled, making a round trip of about one mile in about 15 minutes.

This dredge worked in Lake St. Peter for a short time in 1901, and dredged 120,600 cu. yds. in 21 days at a cost of $3,054.88, or 2.53 cts. per cu. yd. The actual working time was 246 hours, giving an average output of 490 cu. yds. per hour.

The new hydraulic dredge, having a proposed capacity of 2,000 cu. yds. per hour, would therefore be called upon to accomplish results much larger in quantity than anything that had been done before on the work.

As far back as 1886 one of the elevator dredges then in use made a record which stood alone. This was made by dredge "No. 9" which, while working in Lake St. Peter, accomplished 886,710 cu. yds. at a cost of $25,723, or 2.9 cts. per cu. yd.*

The excellent work already done by these dredges rendered the task of improving upon them, by the proposed hydraulic dredge, the more difficult. The records for economy already cited, which were made by dredges "No. 9" and "Aberdeen," were indeed hard to surpass, and have been rarely surpassed by any dredges in the world. The new dredge would be more costly than its predecessors, and manifestly, unless it could show considerably better results, not only in quantity, but in economy, would not fulfil the expectations concerning it.

It was recognized that a hydraulic dredge of this type is a special tool, that is to say, it would not be capable of doing the variety of work that the elevator dredge can do, or work in very hard material. Nevertheless the magnitude of the work in Lake St. Peter alone, and other places where suitable material exists, was sufficient to justify the construction of the dredge.

The state of the art of building large hydraulic dredges at this time, showed that it was possible to employ pumps of large power and capacity, and to deliver material through floating pipe-lines to a distance sufficient to meet the conditions of the present case. The great dredges of the Mississippi River (several of which were designed by the writer) contributed much useful data and experience.*

There, dredges were able to maintain a capacity of 1,500 to 2,000 cu. yds. per hour deposited 1,000 ft. The material was sand, the depth 10 to 18 ft., and the cut made was a shallow trench by straight forward feed. Sand, however, is easier to dredge than clay, and these Mississippi dredges only worked to half the depth and deposited the material at half the distance which would be required on St. Lawrence. Furthermore, the Mississippi dredges only made a cut 30 ft. wide at one time, whereas it was here required to make a cut 700 ft. wide. It was necessary, therefore, to adopt a lateral feed instead of a straight forward feed, and also to apply mechanical excavation which would cover the ground. No hydraulic dredges had done any successful work in clay, and attempts in this material had been abandoned on account of the clogging up of the apparatus. No examples existed of long distance pipe-line dredges of large size which made wide cuts. Large dredges in America which discharged through pipe-line either anchored by spuds making a radial cut, or by mooring lines, making a straight forward feed. Sand-pump hopper dredge practice of European designs offered no useful points. Here was, then, the necessity for a new application of the hydraulic principle of dredging, the points of novelty being, 1st, the lateral feed of 700 ft. width, while discharging to a long distance through a pipe-line adapted to such movement; 2d, cutting mechanically over every foot of the ground in blue clay, and to do this without clogging; 3d, the construction of a pipe-line that would be capable of standing some stress of weather and wave-action.

To this extent, therefore, this dredge was experimental, and the present paper will describe the result of the experiments and the methods adopted to improve the detail parts after testing. The writer's observation of the elevator dredges in Lake St. Peter led him to conclude that here was a clay deposit which could be worked successfully by the hydraulic method if the proper apparatus for cutting or digging it were employed. The clay is of a soft, unctuous nature, sometimes partly siliceous, bluish in color and of a character suitable for brickmaking, or pottery. It dumps well from the buckets of a ladder dredge and slides readily down the chute into the barges in chunks, frequently the whole size of the bucket and showing the markings of the rivets. The problem in the new hydraulic dredge, therefore, was to cut this clay regularly and uniformly and feed it into the mouth of the suction pipe without clogging. Once there, it would slide freely along and be discharged without difficulty, and by making the pipe of large diameter and the dump with passages of large section, the clay could go through in lumps even more readily than sand or finely divided material of like nature, which would tend to precipitate. Thus the hydraulic apparatus is used, not for dredging but for purposes of transportation only.

In considering the question of capacity, the dredge was designed to have a theoretical rate of 3,000 cu. yds. per hour, and it was deemed that this would be sufficient to give a working rate of 2,000 cu. yds. per hour, including the delays incident to regular work, but not counting delays from exceptional causes, storms or repairs. The rate required a section of cut 5 ft. by 6 ft. by a feed of 45 ft. per minute, equal to 3,000 cu. yds. per hour. It was, therefore, necessary to provide a cutter capable of dealing with that section and with plenty of margin to spare, and to provide means for feeding it 450 to 700 ft. across the channel at the required rate. As this involved traversing the entire dredge broadside at that rate, and dragging the semi-submerged pipe-line after it, the power required for this purpose would be quite large, and produce a corresponding necessity of providing strong anchorage to the mooring lines, by which the traversing movement was to be effected.

In considering the movement of the pipe-line attached to the dredge, advantage was taken of the fact that there is a more or less constant current of ½ to ¾ mile per hour in the lake. This is due to the discharge of the river, and is modified by winds and sometimes by tides to a scarcely appreciable extent. The tidal variation at Quebec, 110 miles below, is 9 to 15 ft., but this gradually becomes less on ascending the river until it becomes lost at the lower end of the lake. The current, therefore, causes the pipe-line to assume a catenary curve of varying tightness according to the travel of the dredge. This is shown by Fig. 1, which is a diagram showing the movement of the dredge and the relative position of the pipe-line.

The current, therefore, was employed to deflect the pipe-line to the form of a loop having slack enough to permit the dredge to traverse 450 ft. In order to utilize the current for this purpose, and at the same time render the

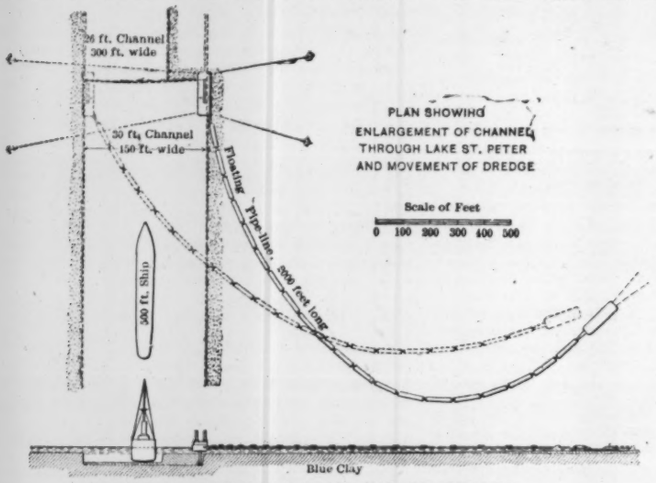


FIG. 1. SHOWING HANDLING OF DREDGE.

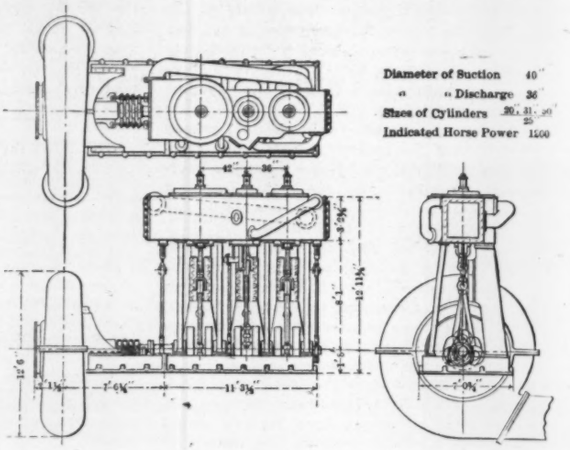


FIG. 4. MAIN ENGINES AND PUMP.

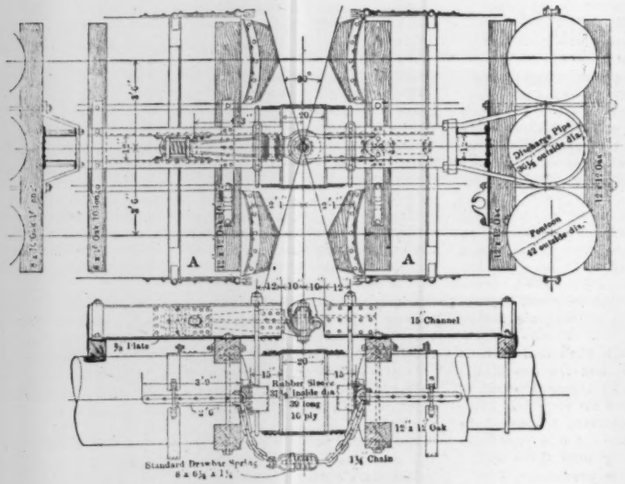


FIG. 3. JOINTS OF PIPE LINE.

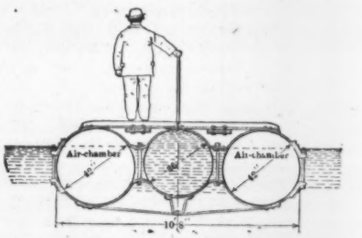


Fig. 2. Cross-Section of Floating Pipe Line.

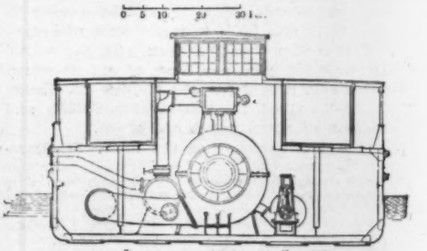


Fig. 5. Cross-Section of Dredge.

*See Reports Harbor Commissioners of Montreal, 1886, p. 80. This cost includes operating expenses of every kind, scow and tug service and repairs, but not interest or depreciation.

*See Trans. Am. Soc. C. E., Dec., 1898. "Dredges and Dredging on the Mississippi," by J. A. Ockerson, C. E., for a full account of these dredges at that date. Much further development has taken place since that paper of which no full account has been published.

pipe-line less exposed to the wind and waves, it was designed to be two-thirds submerged. The weight of a large steel pipe filled with water and mud is very great and would require very large pontoons to carry it in the air, but by partially submerging it the buoyant power required is much reduced.

The form of pipe-line adopted is that of a central conduit, 36-in. diam., carried by two cylindrical pontoons or air chambers 42-in. diam., the three being bound together by truss-frames clamped upon them as shown in Fig. 2. In this way no bolts or rivets are put into the air chambers, and they may be readily taken apart.

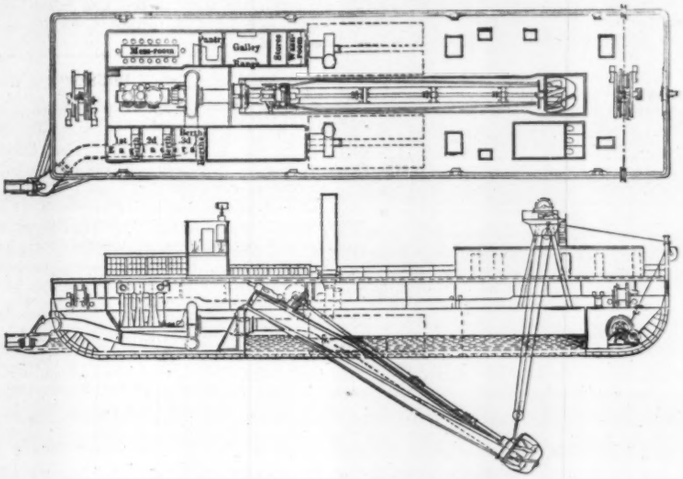


FIG. 6. PLAN AND ELEVATION OF DREDGE.

The pipes were made up in 100 ft. sections and four sections of 50 ft. were made with the idea of putting them in that part of the pipe where greater flexibility was required. It was found, however, that these 50 ft. pipes did not stand the sea as well as the 100 ft. sections, and that moreover sufficient flexibility could be had without them. They were accordingly joined together and converted into 100 ft. sections.

The joints connecting the 100 ft. sections were at first made by uniting them with a forged steel pin-connection over the rubber sleeve, thus relieving the rubber sleeve of all strain due to tension of the pipe and permitting the required angular movement. These joints were not strong enough and were found to be too rigid in wave action, and caused heavy strains to be set up, which broke some of the joints. They were temporarily repaired for the first season, and during the winter of 1902-3 new joints of special construction were devised by the writer designed on the ball-and-socket plan to permit of universal movement to a moderate degree, and also fitted with draw-bar springs to absorb the variations of length due to surging and pitching. The ball-and-socket principle was embodied, not in the pipe itself, but in a strong steel frame above the pipe, which was connected by rubber sleeves in the usual way. This has proved entirely successful and the practical result is that the dredge is capable of continuing at work in all but the heaviest weather. The general construction of the pipe-line and joints are illustrated in Figs. 2 and 3. The ball end of the joint is solidly riveted to the frames on the pipe, while the socket end is fitted to slide in a casing or frame and its movement is resisted by springs, as shown. These springs are two in number and are heavy car springs. They are 6¼-ins. diam. and 8 ins. long, and made of round steel, 1¼ ins. diam. The springs are carried between spring-plates, resting against stops in such a way that the springs are compressed for either thrust or pull of the draw-bar, and the whole arrangement is built in the very strongest manner of steel, and each joint is strong enough vertically to carry half the entire weight of a pontoon upon it. In other words, should the entire buoyancy be removed from one pontoon for 50 ft. of its length by the trough of a wave, its weight could be rested upon the adjoining pontoon with safety.

This pipe-line has now been tested during the working season of 1903, and no breakage or failure of these joint connections has occurred, neither does the ball-and-socket arrangement show appreciable wear.

The elevator dredges which are used on the lake, load into barges and can work in a moderate sea, but have to stop work when the surging of the barge against the dredge becomes too great. It was predicted that a flexible pipe-line could never be made a success in Lake St. Peter, as it would be impossible to maintain it in the waves and that more time would be lost on account of weather than is the case with the elevator dredges. As a matter of fact the position has been reversed, and with the improved steel connections the dredge suffers less delays on account of the weather than the barge-loading dredges.

In order to provide flexibility of the pipe at the point of leaving the dredge a swivel elbow is employed, and the first length of pipe is short and connected to the elbow by a pair of hinges. The axis of the hinges is horizontal while that of the swivel elbow is vertical; thus the movement of the pipe is universal. The pipe leaves the dredge on the corner in order to permit the pipe to radiate from the dredge at any angle through three-fourths of a circle. The horizontal hinges at the swivel elbow will permit the main pontoons to have a vertical or wave movement of 5 ft.

At first the discharge-pipe left the dredge through the stern near the center of its width, it being supposed that the pipe would always drift downstream with the current, or could be anchored in that position. Such, however, proved not to be the case, as a strong wind astern would temporarily deaden the current and cause the pipe to drift upstream. The position of the point of leaving the dredge was therefore changed to that shown on the plans, with a swivel elbow which permits it to radiate at any angle through three quarters of a circle. This arrangement is entirely satisfactory. No anchorage is used at any intermediate point of the pipe. It is attached at one end to the dredge and at the other by a short cable to a scow, the entire 2,000 ft. being free to drift as it pleases. The scow is fitted with a steam winch, by which its own anchorage is controlled. It has two anchors with wire cables, 1¼ ins. diam. and 2,000 ft. long. These can be hauled in and paid out as required, and this movement serves both to distribute the material, to avoid piling up above the surface of the water, and also to regulate the tension of the pipe when the dredge is making a very wide cut. In places when the cut is 750 ft. wide the pipe tightens up to almost a straight line when the dredge is at the far side. The scow anchorage permits considerable freedom of movement and when necessary the operator on the scow pays out on his anchorage to relieve the tension and permit the dredge to make the cut.

The anchors used for holding the dredge are of large size to hold well. The side anchors and the bow anchor are alike as the strain is fully as great on the side anchors as on the head line. There is also a stern anchor worked by a special winch which acts like a towing engine, in that it hauls in and pays out the line automatically as the dredge traverses its cut to suit the varying length and keep a constant tension.

Turning now to the dredge itself, the general form and arrangement will be seen by referring to Fig. 6. The hull is of steel and is 160 ft. long, 42 ft. beam, 12 ft. 6 ins. deep. The plating is generally ½ in. thick on the bottom and ⅜-in. on the sides with 5-16-in. deck. The hull is rounded at the bilges but is rectangular in plan with rounded ends in side view. There is a central opening, or well, through which the suction-pipe works. This well is 8 ft. wide, except at the forward end where it is 10 ft. wide to admit the cutter, and it is of sufficient length to receive the pipe. The suction-pipe is formed of a rectangular steel box girder of great strength, and having its lower horizontal web extended in width so as to fit between the sides of the well. The flanges of this horizontal girder are formed of two angle irons, 5 × 5 × ½ ins., covered with a plate 12 × ¾ ins., which bears against the sides of the well. This is for the purpose of withstanding the great lateral strain due to feeding the dredge sideways and with the cutter in contact with the bottom. The dredge being designed to work at a depth of 50 ft., the suction-pipe forms a lever within the hull and both the hull and the attachments of the pipe thereto, are of great strength to withstand the stresses due to contact with the bottom in a seaway and due to the lateral feeding. The suction-pipe is hinged to the hull at the deck by means of massive steel hinge castings, and a steel bulkhead extends the entire width of the hull at this point. The sides of the hull are extended above the deck to form a solid steel bulwark entirely around the dredge, the hand-rail being formed of an 8-in. bulb angle, finished on the outside with 2½-in. half round. These bulwarks form a protection against the seas which sometimes break over the dredge.

The suction-pipe is suspended from a double steel A-frame over the forward end of the well, and the lifting winch for raising and lowering the suction-pipe is carried on top of this frame. The suspension tackle is formed of two sets of heavy wire rope tackle; the diame-

FIG. 7. VIEW SHOWING PIPE LINE AND STERN OF DREDGE.

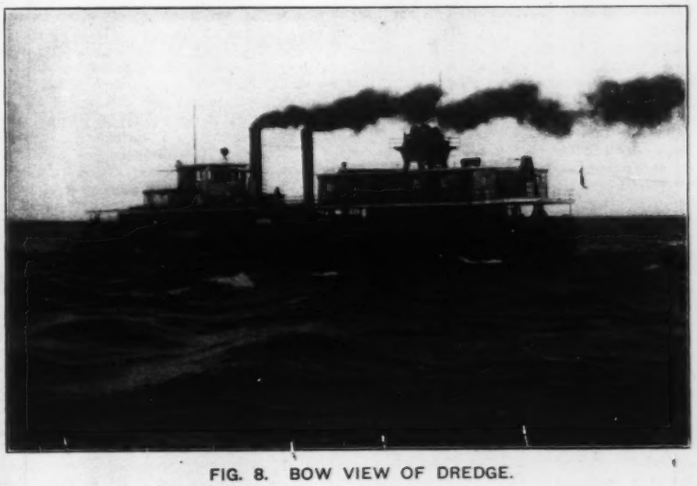


FIG. 8. BOW VIEW OF DREDGE.

THE DREDGE "J. ISRAEL TARTE" AT WORK IN THE ST. LAWRENCE RIVER.

ter of the ropes being 1⅝ ins. The sheaves are of cast steel with turned grooves and brass bushings. The hauling parts of this tackle in this way pass direct to the drum of the winch without the intervention of any idler sheaves as would be the case if the winch were located below the deck. This arrangement has the further advantage of getting this winch out of the hull where it would occupy valuable space.

The main engines are of the triple expansion marine type, having cylinders 20, 31 and 50 ins. diam., by 25 ins. stroke. They are adapted to run at 150 revs. per min., with 150 lbs. of steam. The engine room is provided with a complete outfit of all the usual accessories including air pump, feed pump, surface condenser, heater, bilge pumps, etc.

The material is excavated by an improved rotary cutter, 9 ft. 6 ins. diam., by 9 ft. long, the weight of which is 10 tons. It is formed of steel blades with specially designed clearance spaces between them, so as to avoid clogging with the material, and the suction-pipe and passages through the pump are made very large for the same reason. The cutter is driven by a pair of engines placed on top of the suction-pipe at the upper end. These engines are of the double tandem type of 300 I. H. P. They are of the most substantial description with all bearing surfaces extra large for continuous heavy duty. The gearing and power transmission for these engines is of exceptional strength and capable at all times of encountering immovable resistances with full head of steam on the engines without risk of breakage. The main gearing driving the cutter is of cast steel, 5-in. pitch and 15-in. face. It is worthy of note that during the whole two seasons that this dredge has been in service no breakage, or failure of any kind, has occurred to any part of the suction-pipe, cutter, or cutter-driving apparatus. This is due to the exceedingly substantial character of the design and construction, and the direct manner in which the strains are met; also to the fact that the engines are the weakest part and can be stalled at any time with safety.

Steam is furnished by four boilers, having collectively 8,500 sq. ft. of heating surface, and adapted for working pressure of 160 lbs. There is coal bunker capacity of 200 tons.

The main pump is of the centrifugal type, having cast steel runner of enclosed type and heavy cast-iron shell. The blades of the runner and the heads of the pump are protected by renewable steel wearing plates in the shell. This shell is exceedingly heavy so that it can stand a considerable amount of wear before it begins to fail, and it is also so designed that the stream of material issuing from the runner does not strongly impinge upon it at any one point. In this way the tendency to wear is greatly reduced as compared with ordinary pumps. The original pump with all its parts is still in use and in good condition, after two years of service.

The whole of the operations of the dredge are controlled from the pilot-house on the upper deck. Here are located the levers for both the bow and stern anchorage winches and the lifting winch for the suction-pipe; also a system of bells and signals to the engine room. The pilot-house is so placed that the operator has an unobstructed view up and down the river; also of the entire discharge-pipe. It is necessary for the dredge to get out of the channel to enable vessels to pass. For this purpose the operator causes the dredge to remain on that side of the channel on which the discharge-pipe is situated and slackens out the breasting lines on the opposite side so that they rest upon the bottom.

The dredge is fitted with complete quarters for a double crew of 36 men, or 18 men on each shift. The dredge works continuously from Sunday night till Saturday night each week, without stopping, except when necessary. Several runs have been made of five or six days without a stop of the main pumping engines, the only interruption being the pause in feeding due to the passage of a ship.

The dredge is attended by a powerful light draft twin-screw tug. The principal duty of this tug is to fleet the anchors as the dredge moves ahead. The side lines of the channel to be made are marked at night by temporary range lights.

Turning now to the results accomplished, the work done during the month of June, 1902, when the dredge began work, was only 93,750 cu yds. This was accomplished in 41¼ hours, or 14.3% of the total working time. It naturally occupied some time to get everything in good working order, to make minor improvements and to train the crew for their work, none of whom had ever operated a dredge of this type before. The output month by month steadily increased until in September, 1902, the quantity was 580,000 cu. yds.; in October 600,000 cu. yds.—this notwithstanding the defects to which reference has already been made, and which were remedied during the following winter. The length of channel deepened in September was 7,800 lin. ft., 325 ft. wide by 5 ft. average thickness cut, and in October, 8,000 lin. ft. The dredge thus demonstrated her ability to deepen the channel to 30 ft. at the rate of a mile and a half per month.

Owing to lateness in starting in the spring and to early stoppage in the fall on account of accident to the boilers, the season of 1903 was very short, being 126 working days. During this time the work accomplished was 2,671,750 cu. yds., scow measurement, equal to an average of 21,200 cu. yds. per day for the season. This includes all delays from whatever source. The best month was September, 1903, when the output reached the phenomenal figure of 757,100 cu. yds. This was accomplished in 25 days of 552 working hours, giving an average rate of 1,646 cu. yds. per hour, or 30,280 cu. yds. per day for the month. Of this time 460 hours was actual dredging, being 83¼% of the possible time. The work done was widening and deepening, at one time, the average thickness of the cut in the deepening being 4 ft., and of the widening, 14 to 17 ft. These figures show what can be done with this dredge when the working time can be kept up to a high average.

No special short time tests were made although log records show rates as high as 2,600 cu. yds. per hour maintained for several hours. The average cost per cubic yard for the year is about 1¾ cts.

Unfortunately, the season was cut short by explosion of one of the boilers, due to low water, causing the loss of two lives. But for this untoward accident the work of the season would have been much greater.

The work of the month of September, 1903, is believed to be greater than that ever before accomplished in one month by any dredge. Larger outputs have been claimed for shorter periods of time and in dredging free sand from shallow depths and delivered to shorter distances. The writer believes that the only proper way to estimate the work of a dredge is to measure the results obtained by the month. A high record may be made for a single hour, or a single day, but the general results may be poor if the dredge has not the ability to maintain a high average. The work done by this dredge is determined by the engineer in charge of the river works who takes the position of the dredge in the channel at a given time, say, the first of the month. On the first of the following month he again takes the position, having also observed its progress from time to time. The quantity of material removed is then determined by the area of the cross-section of the cut made, multiplied by the advance actually accomplished during the month. In the quantities as given the volume thus determined has been increased from place measurement to scow measurement, place measurement being 80% of scow measurement. This ratio is based on actual experiment and is for the purpose of comparing the work of this dredge with the other dredges on the river, all of which work by scow measurement. As the material is blue clay, which remains in place and leaves a cleanly defined bank, the cross-section of the cut can be determined with reasonable accuracy, and in a ship-channel 18 miles long, through level flats, it is very uniform and there is no chance for any considerable errors to be made.

The accompanying table gives a comparative statement of the results of short time tests of the "Tarte" and two of the great dredges on the Mississippi. By short time tests is meant 12 to 24 hours. Many official tests of dredges on the Mississippi were made by pumping into barges so that the volume of sand and water could be accurately measured. Much useful data was secured in this way, but as the duration of such tests was only two or three minutes, the writer does not regard them as a valuable index of the working capacity of the dredge. The data given for the "Tarte" was derived from the daily log of the dredge, giving hours worked, distance covered and volume dredged. It does not therefore represent a "test" strictly so-called, but is one sample among many similar ones of what may be considered a good day's run under working conditions. The data for the "Delta" and "Epsilon" is taken from a special test recorded in Annual Reports, Chief of Engineers, U. S. A. 1899, Part V, p. 3495, for the purpose of ascertaining the performance under working conditions. These results likewise do not represent the utmost rate of which the dredges were capable, and it is recorded of the "Delta" that for a short time the capacity reached 2,550 cu. yds. per hour. The other dredges also would probably show a higher rate for a short time under the most favorable conditions.

Comparative Short Time Tests of Dredges.

Dredge.	Cu. yds. per hour.	Distance deposited. ft.	Diam. of discharge pipe. in.	Indicated horse-power.	Steel Hull. Length. ft.	Beam. ft.	Depth. ft. in.	Cu. yds. per H.-P. per hour.	Depth of dredging.	Kind of material.
Delta	1,259	1,000	34	1,050	175	38	8 4	1.19	16 to 18	Sand
Epsilon	1,305	1,000	32	748	157	40	7 9	1.74	16 to 18	Sand
J. Israel Tarte	2,106	2,000	36	980	180	42	12 6	2.15	35	Soft blue clay

MOVING A BRICK HOUSE ON A BARGE.

One of the most remarkable examples of house-moving of which there is a record, was carried out in April last by the Kress-Hanlon Co., of Pittsburg, acting under the orders of the H. J. Heinz Co., of Allegheny, Pa.

The Heinz homestead and the birthplace of the founder of this now mammoth manufacturing plant, was situated at Sharpsburg, on the Allegheny River, over seven miles distant from the works of the company referred to. In this house the present H. J. Heinz started his now famous pickle business; and to gratify his feeling of pride in the growth of the business, Mr. Heinz determined to remove the house bodily to the ground adjoining one of his present buildings.

FIG. 1. THE HEINZ HOUSE CAUGHT BY A FLOOD WHILE BEING MOVED TO THE RIVER BANK.

As an engineering feat the house-moving is worthy of note. The house was a two-story brick structure, weighing 160 tons in all, and it was situated 800 ft. from the river bank at Sharpsburg. The house was jacked up from its foundation, turned around and was gradually rolled on a line of blocking to the river bank. While in this position a sudden flood compelled the cessation of work, and the water rose as high as the first story windows.

When the flood subsided the difficult feat was performed of rolling the house on to the deck of the largest coal barge obtainable, and this was finally towed to the nearest point on the river to the Heinz plant. In passing under the 43d St. bridge, in a high stage of the river, there was but 6 ins. headway to spare. The house is now established on new foundations at its new site. The transfer was made without a crack appearing in the brick walls.

THE USE OF INFERIOR TIMBERS FOR STRUCTURAL PURPOSES.*

During the early history of the lumber trade there was no question on the part of the manufacturer but that he could produce almost any kind of lumber for which he might receive an order. But in the case of white oak

*From a paper read before the National Lumber Manufacturers Association, at St. Louis, by Mr. Hermann von Schrenk, of the Bureau of Forestry, U. S. Department of Agriculture, Washington, D. C.

and the same will be true of pine before long, it has already become true of white pine) the consumer can no longer go to the manufacturer with reasonable assurance of getting what he wants. This is true to a large extent because of the increase in the demand and an even proportionately greater decrease in the supply of forest products, and the situation is fast assuming a phase

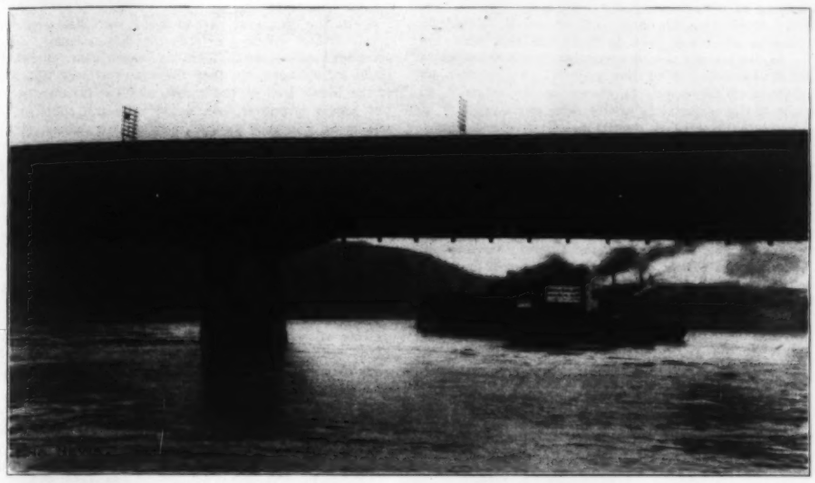


FIG. 2. THE HEINZ HOUSE FLOATING UNDER 43D ST. BRIDGE, ALLEGHENY.

of what the consumer can get as distinguished from what he wants.

The question of the use of inferior woods for some time has been prominent in the work pursued by the Bureau of Forestry. We have tried to keep in mind the relations which existed between the use of high-grade woods and the possible substitution of lower grade timbers for different purposes. The buyer has become accustomed to certain qualities, possessed by high-grade woods, such as strength, ease of finishing, long life and other qualities which go to make up a high-grade material, but the time has arrived when he is no longer in a position to get such material easily.

Questions concerning gum and loblolly pine are coming to the front more and more. Manufacturers of cars, and others, are asking regarding the value of inferior timbers for car sills and structural uses of all kinds. The three problems we have started to investigate are briefly:

1. What are the strength values of the various inferior timbers; 2. What are the lasting powers, both in the natural state and when treated chemically; 3. How more economically to use the waste products of both low-grade and high-grade material, thus bringing about the utilization of all the wood in the tree, including tops, branches and slabs.

The preservation of wood, while practiced a great many years, both in this country and abroad, is still in such a chaotic state that very few know practically what to do. We are trying to test the various forms of preservative processes used both in this country and in Europe, to test the relations between strength and chemical treatment of methods for increasing the stiffness. We are starting in these investigations in the south with gum, beech, loblolly pine and red oak; and on the Pacific coast, with western hemlock, and certain others of the market timbers in use there.

Regarding the strength of timbers, there have been a great many tests made, but they are of such a character that it is difficult to depend upon them. They have not been made with much system. The specimens have been taken without regard to the character of the test to be made. Many woods have received a reputation for being stronger than they are, which has hurt them when they have failed to come up to the expectations; other woods have been classed too low. I have at hand a few of the results which we have obtained during the past year.

Loblolly pine has not only a wide range of growth, but a wide range of structural merit. It is found locally on the markets of Washington and Norfolk under the name of Virginia pine in small sap sticks 8 × 8 ins. or 10 × 10 ins., showing almost entirely sapwood of such a rapid growth that sometimes only four rings occur in 3 ins. This is a second growth timber and usually very knotty. The same species occurs in the Charleston market and from there is shipped to Philadelphia and the north under the name of North Carolina pine and shows a large-sized lumber, fairly free from knots, somewhat close ringed and of a high order of structural merit.

The loblolly pine as a tree is prolific and a vigorous grower and successfully holds its place in competition with other species in the forest. In the operation of conservative forest management, when the lumber companies look upon their forest holdings as part of their plants and reap perpetual harvests of timber therefrom, they will concern themselves with loblolly pine. It is therefore a timber which engineers and architects may expect to find on the market for an indefinite period. The chief objection to loblolly pine is that, being usually sapwood, it decays rapidly when exposed under certain conditions. It is, however, a timber that may be treated with preservatives very successfully. Some difficulty is experienced in preventing the wood from staining in the South Atlantic states, but if the timber is kiln dried it retains the pleasing grain and the clear white finish to be found in the sap wood of the species. It is consumed very largely in the Philadelphia market for joists and mill construction.

Engineers have been for a long time specifying long-leaf pine as the standard material for construction, and it is the opinion of most of them that a wood of quick growth has little merit. It is undoubtedly true that there is no structural wood that approaches long-leaf pine for strength and durability, but for indoor use or for service in which severe shocks do not come on timber this quick growth loblolly pine offers one of the cheapest and most desirable building materials. Let us have some conception of the relative strength of joists of long-leaf and loblolly pine. Let us compare the loads which would rupture two air-dry joists 8 × 14 ins. in cross section and 16 ft. span. One joist is of long-leaf pine of good merchantable quality, showing two-thirds heart on faces, free from shakes that show on the surface or through shakes and unsound knots. The other joist is North Carolina loblolly pine of square-edge grade, showing sap on all faces, free from through shakes or unsound knots but of rapid growth. The long-leaf pine joist will weigh 700 lbs. and contain 133 lbs. of water. The North Carolina loblolly joist will weigh 500 lbs. and contain 87 lbs. of water. The long-leaf pine joists will stand 44,650 lbs. center load before failing and will deflect 2¼ ins. at the time of failure. The loblolly pine joist will carry 32,650 lbs. and will deflect 3 ins. To state the matter in another way: if the loblolly pine joist is 8 × 14 ins. in cross section, the long-leaf pine joist will be 8 × 12 ins. for the same strength.

The red fir is a wood that is found from the southern part of the state of Oregon up to Vancouver; from the west slope of the Cascade Mountains to the coast. Fully 90% of the timber in Oregon west of the Cascades is this red fir, which is sometimes called Douglas spruce, Oregon pine, and Oregon fir. It grows to a large size, the old trees being 10 ft. diameter. The wood varies between a somewhat coarse-ringed growth to a hard fine-ringed variety. The wood, however, is never, even in the fine-ringed growth, as hard as long-leaf pine of an equal rate of growth. It is found in the red and yellow colors, and the two colors may be found in the same tree. There is a great difference in the relative hardness of the rings of red fir and also in the shrinking qualities, so that the wood when dry is apt to be of a ribbed character, and hard rings stand out from the softer rings. The wood is more durable than white pine and less durable than long-leaf pine. The great length in which the wood can be sawed perfectly free from blemishes and clear from knots renders it available for special uses. It is already a competitive wood in the markets of Chicago and as far east as Pittsburg. Take an 8 × 14 in. red fir joist, merchantable grade, being of sound lumber, free from shakes, large, loose or rotten knots, allowing sound knots, pitch seams, sap on corners one-third width and one-half thickness. This joist will carry 30,500 lbs. at the time of failure, and will deflect 5 ins. It will weigh 400 lbs. and contain 62½ lbs. of water.

The western hemlock has suffered in reputation because of eastern hemlock. The western hemlock grows in large sizes up to 13 ft. in diameter with a height of 250 ft., and is found in Washington, Oregon and Vancouver, intermixed with red spruce and cedar. It is a vigorous growing tree and after the red fir has been cut down

FIG. 3. CROSSING RAILWAY TRACK ADJACENT TO HEINZ FACTORY.

most of the young growth seems to be hemlock. It is not so white or hard as Pennsylvania hemlock. Perhaps it approaches more the hemlock brought from Canada, being softer. It has a distinct odor and is practically immune from the attacks of insects. At the present time it is cut and appears on the market as second grade red fir, not usually being cut or sold under

its own name. It has been used for trestles, locally by mills on the Pacific coast and furnishes a very desirable and pleasing finished wood. An air-dry joist of hemlock of merchantable grade will carry 28,300 lbs. before failing, and will deflect 1½ ins. It will weigh 500 lbs. and contain 112 lbs.

Summing up then, we may say of these four species—long-leaf pine, loblolly pine, red fir and hemlock the relative depth for equal strength will be as follows (taking the width of the joist as 8 ins. and the span 16 ft.): 14 ins. for long-leaf pine, 16 ins. for North Carolina loblolly pine, 16 ins. for red fir, and 18 ins. for hemlock. The weight per 1,000 ft. B. M. of perfectly dry timber will be as follows: 3,820 lbs. for long-leaf pine, 2,580 lbs. for North Carolina loblolly pine, 2,120 lbs. for red fir and 2,170 lbs. for hemlock.

A PROPOSED TEST FOR DETECTING BRITTLENESS IN STRUCTURAL STEEL.*

By J. P. Snow,† M. Am. Soc. C. E.

It is felt by many users of structural steel that mill inspectors should give more attention than is now usual to the detection of brittleness in our bridge material. Brittleness may be due to improper heat treatment or to segregated carbon or phosphorus. These defects may occur in material rolled from part of the slabs derived from a given ingot while material rolled from the same melt or even from other slabs of the same ingot may be exceptionally good. If the ordinary tensile and bending tests of the heat from which the material in question is derived should be taken from those parts where objectionable segregation had not occurred and which had received proper heat treatment, the results would not expose the brittle features of the part supposed to be bad.

The desideratum is a practicable method of testing, which will furnish the inspector a means of detecting brittleness in any piece that comes from the rolls that he suspects may be objectionable. The object of this paper is to suggest a scheme which seems to me to answer this requirement.

Prime essentials of a test of this sort are simplicity and quickness of accomplishment. Mill men say, with reason, that they cannot hold stock until machine-finished samples can be prepared and elaborate tests made. I am informed that much of the material now being used is many miles from the mill, on its way to the fabrication shop, before the testing-machine work is done on the specimens that are supposed to determine whether the material is to be accepted or rejected.

Determining the temperature of the metal after or before the last pass through the rolls is neither efficient, precise nor conclusive. Delaying the piece before the last pass until the right temperature is reached refines only the outer skin of the material. It is not the function of buyers to tell the manufacturer how he shall produce his steel or at what temperature he shall roll it, but rather to ascertain if the product which he offers is suitable for their uses. This can be best accomplished by testing the finished product in a direct way.

The scheme here in proposed is in substance a nicked-bending test on crop ends of plates and shapes as they are trimmed at the rolling mill for shipment. A nicked bend is proposed because the object is not so much to see if the specimen will bend without fracture, as to open up the grain of the steel, to see whether it is fine and silky or coarse and crystalline.

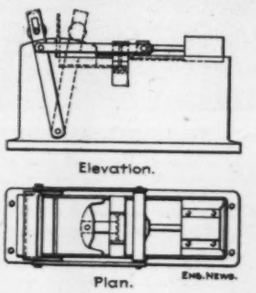
It is proposed to take a generously wide piece of crop end, so that the effect of the shear at the edges will not affect the result. It is deemed unfair to the manufacturer to depend upon narrow sheared specimens for this scheme of bending, because the injurious effect of the shear should not be assessed against the quality of the steel. Punched specimens are ruled out for the same reason. If narrow specimens with milled edges or punched specimens with reamed holes are used, the vital element of quickness of accomplishment is lost; for, while the specimens are awaiting their turn at the finishing machine, the plate or shape from which they are cut is loaded for shipment or covered up in a pile of other stock. The scheme proposed will tell its story, if desired, before the rolling heat has left the piece. It can be executed and a decision reached almost as quickly as the surface inspection of a plate can be made.

In detail the scheme is: to shear from the crop end a piece say 12 ins. wide and nick it about 3 ins. from one edge, preferably across the direction of the rolling, with a tool made for that particular thickness; clamp it in a hydraulic vise and bend the free end over by power. The sketch shows in outline a possible bending vise. Both the vise and the bending roller are to be actuated by hydraulic power, which is always available in a rolling mill. The nick is proposed to be made with a tool like a blacksmith's flatter having a raised bead on its face.

Nicked bending tests by impact have been recommended in the past by many investigators. In 1892 Le Chatelier advocated such tests before the French Committee on Methods of Testing, and since that time work on these lines has been done by Barba, Considere, Le Blant, Aucher, Fremont, Osmond and Charpy in Europe, and by S. Bent Russell and others in this country. All of these experiments sought to determine the resilience of the material by impact tests, thinking to replace the ordinary tensile tests by these determinations. But as shown in Johnson's "Materials of Construction," impact testing is surrounded by so many uncertainties that it has never been found commercially practicable for structural materials. Evidently the constant effort has been to make the test prove too much. In the scheme herein advocated the object is not a complete physical test of the material, but simply an examination of the grain, as shown in the fracture, to ascertain if the material is brittle from any cause.

To insure a fracture in ductile material, the deformation must be localized by a nick. The form of the nick, its depth and shape must be determined by experiment, but for a beginning it is suggested that a depth of one-eighth the thickness of the specimen be tried; the bead with which the nick is made to have the form of the Whitworth screw thread. Investigation may show that a single size of nick may be used for different thicknesses, but it is probable that each thickness should have its particular size. The nicking die may be struck by hand hammers or a light quick-acting steam hammer may be provided for the purpose.

As to the method of producing the deformation, it is possible that the distinctive difference between material



Elevation and Plan of Bending Vise for Making Nicked Bending Test.

that is good enough to be accepted and that which ought to be rejected cannot be brought out by making the bend with a press. It may be necessary to use impact, as was done by Fremont in a series of experiments described by him at the Budapest meeting of the European Railway Congress.

These experiments show that a ductile steel may be broken short off by a blow of sufficient velocity. We know that ordinary structural steel when nicked and bent will invariably break unless it is exceptionally ductile and in very narrow specimens; hence, it seems that a press bend on a wide specimen will certainly produce a break and show up the grain. A press bend, if effective, is preferable to a blow on account of its more certain action and because it does not need adjustment for different thicknesses as would be needed if the bending was done by a blow.

It is believed that a test of this kind will expose coarse grain in steel, due to improper heat treatment, segregation, bad chemistry or any defect that tends to brittleness. The engineer may, under present specifications, demand certain chemical and physical qualities when buying steel. He may not be justified in prescribing the exact ratios of the many "ites" or the precise "eutectic values" of the various compounds that enter into the material which the manufacturer gives him for steel, but he may reasonably demand simple tests like that advocated here to satisfy himself that the material is free from brittleness.

In the past when puddled iron was the usual structural material, engineers depended largely upon bending tests to ascertain the quality of the output of the mills. Our member, Mr. C. C. Schneider, has told me that he cared little for the tensile strength, elongation and other physical features of wrought iron as determined by the testing machine, but that he set great value on cold bending tests of scrap ends. Sir Benjamin Baker, when engaged upon the Forth Bridge, stated that he placed more reliance upon bending tests of mild steel than upon testing-machine determinations. With the steel of the present day we must test for ultimate strength to secure a grade that can safely undergo the ordinary shop manipulations and examine the chemistry to secure uniform composition; but have we not too much lost sight of the valuable old-time feature of bending? The ordinary plain bending will not always show us the grain of the steel. In fact the width of the specimen and the radius of the bend are so selected in our usual specifications that ordinarily good material will bend without fracture. Its ability to do this is the gage for acceptance. To this end the sheared edges are planed, which defeats the very purpose of the test desired on account of the time involved in the operation. Moreover, we bend but one specimen for each melt, which assuredly does not attempt to control the rolling heat.

It is true that the proposed test may involve closer attendance of the inspector at the mill than our usual commercial testing requires, and it may be impossible to define the lines by which an inspector shall be governed in rejecting material, as sharply as can be done under our present system, but the inspector's attendance can be arranged for and the results reached by Fremont give us a clew to what may prove to be a proper criterion for acceptance or rejection.

If, in the proposed nicked bend the specimen should break around Fremont's "ellipse of enlargement," instead of square across, or if it did not break clear through, we could safely conclude that the material was not brittle. If the break was square across and the fracture silky or but partly granular, we could presume that the heat treatment was good and segregation not excessive; but if the fracture showed crystalline facets or appeared dull and cokey it would be ground for rejection. After sufficient careful experimenting I am sure that workable limits can be fixed upon for the guidance of inspectors. It is possible that thick and thin material cannot be brought to follow the same law, but rules can be established for varying thicknesses. Material that is known to be good and that which is known to be bad, both from overheating and segregation, can be experimented upon and safe extremes established.

Metallurgical literature is filled at present with complaints of poor structure in rails and to some extent in other steels. The complaint is not quite so common in regard to structural steel, for the reason, probably, that it is usually in thin sections which cool to a lower temperature than thick ones while passing the rolls. It is the case, however, that rolled beams have sometimes proved so brittle and untrustworthy that some engineers dislike to use them in railroad bridges. It is likely that the principal reason for this condition is too high heat during rolling due to their heavy section. If the crop ends of such beams are sheared up so that a section of the web or flange can be nicked and bent in the proposed machine the coarse structure if it exists will surely be exposed and the beam saved from discrediting its species when put into service.

A similar test on crop ends of rails could be made while the rails were passing the straightening press and many of those having coarse structure at center of head, open grain, lamination, pipes, sulphur flaws or other defects that one drop test in five heats does not detect would be saved from going into the track and causing trouble for both user and manufacturer.

The above scheme of testing is submitted for consideration. It is intended to supplement the usual tests for physical qualities and is suggested as a means of satisfying buyers of steel that their material is sound and free from brittleness. It is cheap in installation and operation, and requires the inspector's continuous attendance at the shearing end of the rolling mill, where he belongs. If properly executed it should tend to allay the agitation that is now going on among users of rails and structural steel in regard to heat treatment, open grain and other rolling-mill defects. If the scheme is objectionable to manufacturers it is respectfully offered for their free criticism.

*A paper read before the American Society for Testing Materials at Atlantic City, N. J., June 18, 1904.

†Bridge Engineer, Boston & Maine Ry., Boston, Mass.

AN ENGINEERING EXPERIMENT STATION has been established by the State of Illinois at the University of Illinois, Urbana, Ill. For the testing equipment of this station, a 600,000-lb. testing machine has been ordered of the Riehle Bros. Testing Machine Co., of Philadelphia. The machine is of the familiar Riehle style, with two vertical pulling screws. The machine stands about 31 ft. above the floor, and is 36 ft. 8 ins. in extreme height. It can take tensile specimens up to 22 ft. long, compressing specimens up to 25 ft. long, and transverse specimens up to 10 ft. long by 3 ft. wide. It is driven by a two-phase induction motor of 15 HP., and by means of change gearing six different speeds can be obtained, from 0.05 in. to 8 ins. per minute. This machine will be the largest testing machine of the screw type ever built. The table is equipped with hydraulic dash-pots for taking up the recoil of the break.

RAILWAY CONSTRUCTION during the first six months of 1904 has been quite active. According to a collation of official reports received by "The Railway Age," no less than 1,937 miles of track have been completed, on 134 lines in 33 states and territories, as indicated in the following table:

Track Laid from January 1 to June 30, 1904.

States.	No. lines.	Miles.	States.	No. lines.	Miles.
Alabama	8	71.45	Missouri	5	249.40
Alaska	1	8	Montana	1	25.
Arizona	3	35.90	Nevada	2	137.
Arkansas	8	72.24	North Carolina.	2	12.
California	5	81.32	Ohio	3	32.
Colorado	3	59	Oklahoma	3	104.50
Florida	6	57.50	Oregon	2	6.
Georgia	4	29.	Pennsylvania	10	107.
Illinois	8	151.30	South Dakota.	1	10.
Indiana	2	14.	Tennessee	8	52.56
Ind. Territory.	2	53.40	Texas	7	234.57
Iowa	2	7.60	Virginia	2	4.50
Louisiana	4	39.	Washington	5	51.00
Maryland	2	7.	West Virginia.	8	61.18
Michigan	1	4.50	Wisconsin	2	6.
Minnesota	6	41.21	Wyoming	1	27.
Mississippi	7	84.80			
Total in 33 states and territories				134	1,937.53

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ADVERTISING RATES will be furnished upon application. "Want" and "For Sale" notices (special rates), see pages 26-27. *The pages for new "Want" "Proposal" and "For Sale" advertisements are held open until Wednesday noon.*

It is gratifying to record that public opinion in New York City appears to be awakening to the need for prompt action with reference to a supplementary water supply, which was set forth editorially in our issue of July 14. On July 20 eight prominent civic organizations of the city joined in a letter to Mayor McClellan, as Chairman of the Board of Estimate and Apportionment. We reprint the substance of this letter as follows:

The undersigned respectfully call the attention of the Board of Estimate and Apportionment to the grave danger confronting the City of New York because of lack of provision for an adequate water supply.

The consumption of Croton water in Manhattan and the Bronx in 1903 was about 270,000,000 gallons per day on the average. The area of the Croton water-shed above the new dam is 300.4 square miles, and the safe yield of this water-shed during dry years, after the new reservoir will be completed, will not exceed 750,000 to 800,000 gallons per day per square mile, or from 270,000,000 to 288,000,000 gallons per day.

In a dry season such as occurred several times between 1880 and 1898, and which is sure to occur again, the total supply of Croton water for Manhattan and the Bronx under present conditions would not be more than 250,000,000 gallons per day—that is, 20,000,000 gallons per day less than the city is actually using at the present time. The serious consequences of such a condition of affairs, not only to the business and financial interests of the city but to the health and safety of the community as well, need not be dwelt upon.

In spite of the saving from waste made in recent years the consumption of water in the Boroughs of Manhattan and the Bronx is increasing each year at the rate of 7,000,000 gallons per day. During the 13 years prior to 1903 the consumption of Croton water in the Boroughs of Manhattan and the Bronx has increased from 140,000,000 gallons to 270,000,000 gallons, or an average yearly increase of about 10,000,000 gallons per day. The consumption of Croton water therefore during the next five years in Manhattan and the Bronx will be about:

During	1904	from	277,000,000	to	280,000,000	gallons per day.
"	1905	"	284,000,000	"	290,000,000	" " "
"	1906	"	291,000,000	"	300,000,000	" " "
"	1907	"	298,000,000	"	310,000,000	" " "
"	1908	"	305,000,000	"	320,000,000	" " "

Without provision for an increased supply of water to meet this increase of consumption, a water famine will surely result with the first dry season.

The situation in the Borough of Brooklyn and in the Boroughs of Queens and Richmond is almost equally serious. Within a few years the entire sources of additional supply for these Boroughs will have been exhausted.

Except for a possible increase for the Borough of Brooklyn, the available sources of additional water supply for the entire city (within the state of New York) lie to the north and northwest of the present Croton water-shed. To get water from any of these sources, it is necessary in every case to build a tunnel through the mountainous country north of the Croton water-shed. Under the most favorable conditions it will take five years to build this tunnel.

To sum up: The city's dire need of more water is known. The available sources of additional water supply are known. A commission composed of three of the most competent and best equipped experts in the country has reported complete and thoroughly worked out plans which, if carried out intelligently, will within the shortest possible time bring these sources within reach of the city and furnish an adequate supply of water to every one of its boroughs. The city has ample legal power to begin the work at once. We would respectfully submit that your honorable board should either adopt the plans submitted in November, 1903, by the Commission on Additional Water Supply, or should promptly give most cogent reasons for rejecting these plans.

The organizations signing this letter include the City Club, the Manufacturers' Association of New York, the Citizens' Union, the Brooklyn League, the Flatbush Taxpayers' Association, the New York Board of Fire Underwriters, the Committee on Internal Trade and Improvements of the Chamber of Commerce, and the New York Board of Trade and Transportation.

That there is no politics in this appeal goes without saying. It is certainly to be hoped that this strong representation by the foremost business interests of the city may induce the authorities to take prompt action for the prosecution of work.

As we pointed out in our editorial two weeks ago, it is not merely public convenience that is at stake but public safety. The "Insurance Press" of New York City, in its issue of July 20, reprints with approval our editorial of July 14, and says:

The comments of "Engineering News" represent engineering opinion. That opinion, of course, is shared by fire underwriters. It is as true as anything can be that the water supply of New York for fire-extinguishing purposes is wholly inadequate. What our engineering contemporary says is an intelligent and reasonable forecast, not an alarmist utterance. . . . All the power of the fire insurance business should be exerted to hasten action by the proper authorities to provide the additional water supply needed.

Many of our readers will remember the great impetus which was given to the art of hydraulic dredging a dozen years ago by the remarkable achievements of the huge dredges built by the Mississippi River Commission. The great hydraulic dredge on the St. Lawrence River, which is described in this issue by its designer, Mr. A. W. Robinson, M. Can. Soc. C. E., appears to mark an advance in the art quite as great as that which was effected by the Mississippi River dredges. This dredge, the "J. Israel Tarte," has the largest capacity of any machine ever made for artificial excavation, and will be doubtless also conceded to be the most efficient machine of this sort ever devised. It is true that in tests lasting a few seconds or minutes, some of the Mississippi dredges, notably the huge "Beta," showed a nominal output much greater than that recorded for the "Tarte," but as a practical dredging machine for week in and week out service, the "Beta" is not entitled to rank in the same class with the "Tarte."

Further, in comparing the capacity of these dredges, full account must be taken of the character of the material moved, and there is the greatest contrast between the tenacious clay in the bed of Lake St. Peter and the fine silt on the bars of the Mississippi River. The latter is so easily moved by the current that it feeds itself to the suction pipes of the dredge. The clay has to be sliced off mechanically from the face of the cut just as much as if the work were done by a dipper dredge, and the water merely serves as a carrier to convey the excavated lumps to and through the pump and along the pipe line to the point of final deposit. It is evident enough that to excavate a cubic yard of the clay represents much more work than to excavate a cubic yard of silt, and with this fact in mind the great advance in capacity which the "Tarte" shows over all previous hydraulic dredges stands proven.

If our statement regarding the efficiency of the machine be questioned, we would remark that the hydraulic dredge is well known to be the most efficient of all excavating machinery; that is, it can move the greatest amount of material over the longest distance with the least expenditure of labor and power. Since the "Tarte" exceeds in capacity of monthly output all previous hydraulic dredges its claim for greatest efficiency must likewise be admitted.

Nor can full justice be done to its designer, Mr. A. W. Robinson, without a word as to what this dredge represents as a feat of mechanical engineering. To design a machine to dig material at the rate of over 2,000 cubic yards per hour, transport it a distance of nearly half a mile, and work continuously day and night, in all weathers, the season through was an advance on existing practice so great that the engineer had to do much of his work without the aid of previous precedents. It is very frequently the case when an engineer attempts such a wide departure from past practice that his first machine is more useful as a guide to indicate what not to do than as a piece of working apparatus. The first large hydraulic dredges on the Mississippi River, for example, developed a multitude of defects when put in service, and required extensive alterations to make them efficient machines.

In the case of the "Tarte" the unsolved problems were as great as those that confronted the designers of the first Mississippi dredges, and that they were so accurately solved that the resulting machine holds the world's record for efficiency is a high tribute to Mr. Robinson's professional ability.

Let us add that, while we are glad to extend this recognition to a Canadian engineer's work, Mr. Robinson belongs almost as much to the United States as to Canada, having spent many years in the United States, and performed an important part in the development of large excavating machinery in this country.

The loss of the ill-fated "Norge" appears to have been due not alone to the error of her navigator in letting the ship swerve out of her course to strike the dangerous Rockall Reef, but to the absence of water-tight bulkheads to keep the vessel afloat after grounding. According to "American Syren and Shipping" the "Norge" was built for freight traffic as long ago as 1881 under the name of "Pieter de Connick," and after weathering the storms and corrosion of the North Atlantic seas for a quarter of a century she doubtless was, as the "Syren" says, "a veritable old iron pot, and it stood to reason that when she smashed a hole in her hull it meant a desperate case."

"Lloyds Register" does not credit the "Norge" with a single water-tight bulkhead, and being built for freight carriage so long ago as 1881, it is quite likely that she had none. Thus her loss in case of serious collision or grounding was almost certain. In contrast with the "Norge" disaster the "Syren" cites two other examples of steamers striking reefs, as follows:

The "Norge" ran on Rockall Reef, stuck for about twenty minutes, backed off and immediately sank in deep water. The steamship "Boston," with some 240 passengers on board, struck a reef near Yarmouth, Nova Scotia, stuck for about twenty minutes, backed off and made her way into Yarmouth safely, not a passenger having to leave her until her pier was reached. Then the "Boston" proceeded as she was, under her own steam, 240 miles across to Boston, where she was docked for examination, and it was found that her stem was twisted to starboard and the bow plates for a distance of 35 ft. were broken or indented.

The Furness Line steamship "Florence" struck the Yellow Ledges, off Grand Manan, remained about 45 minutes until the tide floated her, and she reached St. John with her fore foot badly broken and some 15 ft. of her keel torn away, while her fore peak was full of water, yet it is stated that little if any of her cargo was injured. The steamers in question were saved by the efficiency of their water-tight bulkheads; the "Norge" wasn't.

There appears to be every probability that South America during the next ten years is to witness a great amount of railway construction. The development of the mineral wealth of the Andes offers one of the most inviting fields in the world for the investment of capital, and such investments will be made as rapidly as stable political and social conditions create the necessary confidence.

The development of the countries on the western slope of the Andes is certain to be greatly stimulated by the building of the Panama canal, by which rapid and cheap water transportation from the ports of these countries to United States

markets will be afforded without the long and dangerous voyage around Cape Horn.

Bolivia has been among the most backward of South American countries in railway development, but it is now stated that arrangements have been completed with a French syndicate, headed by interests identified with the Creusot Works, for the investment of some $35,000,000 in extending the Bolivia railway system, of which $10,000,000 is to be furnished by Bolivia in accordance with the terms of settlement of the Acre boundary dispute with Brazil, and the balance is to be furnished by the French syndicate.

It seems well, however, to supplement this note by a word of caution. The investment of capital in these countries is bound to be attended with more or less risk, and hence is suitable only for those with money enough so that they can afford to run the risk of loss for the chance of large gain. As for the engineer with little or no capital at command, he should be very sure before starting for any South American country, just what his employment is to be, and under what conditions he is to earn his living.

Further than this, in the tropical regions of South America a man should understand just what risks to his life and health he is running before undertaking any venture. U. S. Consul Ayme, of Para, Brazil, has just sent a vigorous report to the State Department warning Americans that the Amazon valley presents no such inviting field for the investment of capital or the settlement of colonists as has been claimed. He cites the case of a young American mechanical engineer who went with his family three years ago to endeavor to establish some profitable business on the upper Amazon. He had had long experience in tropical countries, spoke the language perfectly and was supplied with $20,000 cash capital. If any man could succeed, says Consul Ayme, this man could; but after three years' endeavor he has given it up and is returning to the United States with the remnant of his capital, esteeming himself fortunate to have escaped with life and health.

Consul Ayme sums up the situation as follows:

> It may be that there are places in Brazil where colonists might do well. Perhaps, but I do not know of any such places. Perhaps there are men who have succeeded here under the conditions of those to whom this report is largely directed. Perhaps, but I cannot learn the names or whereabouts of such men. But with stories of discouragement and despair, stories of failure and disaster, I am all too familiar. I shall not willingly add one single victim more to the long list of disappointed seekers after the tropical El Dorado.

THE DEVELOPMENT AND HANDLING OF LOCAL RAILWAY TRAFFIC.

The development of short distance local traffic and the economical operation of traffic of this kind on branch lines and on individual sections of main lines, are matters which have hitherto been to a large extent overlooked on American railways, but which may force themselves into prominence in the near future. With the same attention given to these problems as has been given to the problem of effecting economies in freight train service, for instance, it is probable that very substantial and important results may be obtained. It is well known that the New York, New Haven & Hartford Ry. is operating certain local lines by electric traction, and the Boston & Maine Ry. owns and operates an electric interurban line (parallel with its steam line from Concord to Manchester, N. H., 18 miles), but these are isolated cases, not indicative of any general attention being given to the matter, and we deal more particularly with the operation of traffic on existing lines.

There has been in general a tendency to reduce the local train service to the minimum, and to operate it with engines and cars relegated to this service as a preliminary to the "bone-yard" or the scrap heap, the idea being to get along as cheaply as possible in view of the small returns. But the experience with electric railways during the past few years has shown that increased traffic facilities cause increased traffic, and that people in the suburbs and rural districts will travel very much more frequently when given an hourly or half hourly service (with stops at road crossings, etc.), than when limited to two or three trains a day, and these trains stopping only at regular stations. In a recent copy of an English railway paper we find it stated that the new traffic superintendent of a minor line in Ireland saw the possibilities of traffic on one of the branches and inaugurated in the winter a train service much in excess of what had been considered necessary even in summer. The result was that traffic on the branch increased very rapidly, and to such an extent that in a few years it was found necessary to lay a second track. While conditions may have been exceptional in this case, it is significant of what may result from increased facilities of travel.

It is quite generally assumed, also, that the operation of local and light traffic is and must be expensive and uneconomical. This is undoubtedly true as long as the present system of operation is continued. A train composed of a locomotive and cars, handled by four or five men, and carrying a few passengers, is necessarily uneconomical, especially when making a few trips at long intervals over a branch line or on a local run on a main line. The wages, fuel and general train expenses will be the most prominent features of the balance sheet.

In place of this suppose that a motor car is installed and kept in continual service. The running expenses may be at once reduced (more than half on an English road which has tried the experiment, as noted in another column), and the revenues will begin to increase because people will begin to avail themselves of the more frequent service. Of course it is not enough to select any piece of line, equip it with any kind of motor car, and wait for the revenue to increase. The matter is a problem in railway economics and practice, and must be studied out like any other practical problem, and in the light of local conditions. A few years ago, several spasmodic experiments of this kind were made in this country, but none of them produced any practical results, and they have all been discontinued. These unsuccessful experiments, which were described and discussed in our issue of February 6, 1902, have tended to throw discredit on the entire proposition. But in our opinion they simply show that the method of solving the problem was incorrect, not that the problem was incapable of solution.

While the broad proposition is true that local traffic may be developed by increased facilities, this will not apply on lines in very thinly populated districts. Even for such lines, however, the motor car system presents advantages in economy, owing to the low cost of operation as compared with that of train service. In many cases in England such motor cars have sufficient power to haul two or three freight cars. A motor car service would also be much less severe upon the track, resulting in economies in maintenance of way and structures. For new lines which are designed to be operated by motor cars a cheaper construction may be adopted and the combined economies in cost of construction and cost of maintenance are of greater importance than economy in cost of train service on lines of light traffic, with only a few trains daily. Those of our readers, who are interested in the question of economical operation of railways of this kind will find it profitable to consider the editorial on "Railways for Light Traffic" in our issue of April 30, 1903. In the present discussion we refer more particularly to lines in districts where there is a probability of developing traffic.

Those who desire to study this problem of the development of local traffic may look in three directions for very valuable information: First, The interurban electric railways of this country (many of them directly paralleling steam railways) show how rapidly a large traffic of this kind may be developed; it would seem that people have been only waiting for the opportunity to travel. This was shown in articles on the interurban system of electric railways in our issue of September 3, 1903. Second, Numerous railways of continental Europe show that motor car or "auxiliary train" traffic can be operated with success on the ordinary steam railways, for they have had this class of service in operation for nearly thirty years, while English railways are now beginning to introduce it. Third, The conservative railways of England are now showing how traffic can be developed and train operating expenses reduced by introducing motor cars both to replace ordinary trains on branch lines and to supplement the ordinary trains for local service on main lines. The case in England is quite remarkable, and but a very few years ago it would have been impossible to induce managers to consider such an innovation. But the railway companies have now been driven to take some action by a serious increase in operating expenses and a sharp competition for their local traffic on the part of electric railways. It was very evident that these new comers did not subsist alone upon the traffic which they took from the steam railways, but that they developed a traffic of their own. The steam railways, therefore, are trying not so much to get back the lost traffic as to develop a new traffic by the introduction of increased facilities. The results of the motor car system appear to have been far more successful, both from a mechanical and a traffic point of view, than was the case in this country.

In an article in "The Engineer" (London), referring to this new step in English railway affairs, wonder is expressed that these motor cars have never before had a trial, although they were advocated 50 years ago. The incongruity of a locomotive with three or four cars making three or four trips a day on a branch line with perhaps a dozen passengers is obvious. The writer expressed the opinion that there was no difficulty in making a car which would carry 40 passengers on any line at a cost of less than 6 cents per train-mile. Mr. Drummond has even brought this down to 5 cts. and 7 lbs. of coal per train-mile with his steam car on the London & Southwestern Ry., while the average for ordinary train service in England is 25 cts. per train-mile. There is danger, the writer thinks, that the thing will be overdone. The traffic manager, finding the steam car a success will demand that it be made larger, forgetting that this means increased weight and cost. As a matter of fact, 40 passengers is the maximum capacity needed, and high speed is not necessary. The steam engine is considered preferable to the oil engine for motive power. This article above referred to relates only to the use of the motor-car on branch lines, but an equally important field appears to be the local service on certain parts of main lines, as in the case of the Great Western Ry., noted in the article in another column. It has also been proposed as a substitute for trains in mid-day suburban service, giving a more frequent and more economical service during the time when the traffic is light but continuous.

In the United States there has been practically no development of the railway motor car since the experiments recorded in our issue of February 6, 1902. One experiment made since that time was the trial of a gasoline motor car on the Tabor & Northern Ry. in 1903. This line runs from Tabor to Malvern, Ia., a distance of only 9 miles, and has a regular schedule of three trains each way daily, the trains being composed of ordinary light locomotives and cars. The idea of the motor car was to give a better and more frequent service at less expense, and at the same time to develop the traffic. The car was built by the Chicago Motor Vehicle Co., which at one time had omnibuses of the same type in service in Chicago. The company is now in the hands of a receiver, however, and we have not been able to obtain any definite information as to the car or its service.

The gasoline engine (which was the invention of Mr. W. O. Worth) was of novel design, but the special feature of the mechanism was the power transmission system, giving a wide variation in speed and power. The connection consisted of a large friction disk mounted on the engine shaft, and a second disk having its rim in contact with the face of the other. This second disk could be shifted laterally, and its speed varied according to its position between the center and the edge of the engine disk. The car weighed 6,000 lbs. empty, carried 20 passengers and had a two-cylinder four-cycle engine with a

capacity of 20 to 35 HP., varying with the speed. The Jamestown, Chautauqua & Lake Erie Ry. (33 miles) is building a motor car, but details are not yet available.

In regard to the competition between steam and electric railways, it may be noted that in England, the promoters of an electric railway cannot obtain permission to build the line if it is shown that it is directly parallel with or competitive with an existing steam road, or that there is no need for increased facilities. It is said that in one or two cases, railways threatened with this class of competition have established a frequent service of motor cars and have shown that no additional facilities were needed by the district to be invaded. In this country, there is as yet (unfortunately) no such check upon the construction of parallel and competing lines regardless of requirements (except in one or two States). But even so, and supposing the branch or section to be paralleled by an electric line, it appears that there is available for the steam railways a means of reducing operating expenses and increasing the revenue by a share, at least, of the new traffic possibilities. It would not pay to increase the number of stops of the through trains, or to operate a frequent service of short distance trains of the ordinary character, but it appears very probable that it would pay in many cases to operate motor cars running frequently and stopping at road crossings as well as stations, thus giving a better service at reduced cost. The motor car system might be also applied to many new lines which cannot now be built on account of the cost of operation in the ordinary way, but on which a frequent or infrequent motor car might be run at very much less cost.

In view of the recent development in this line on English railways, as above noted, together with the generally satisfactory results reported, and the unsatisfactory results of several American cars (as reviewed in our issue of February 6, 1902), we have been led to investigate the matter, and in our article in another column we present information concerning the cars themselves and the service operated on various European railways at the present time. It will be of interest here, however, to briefly note the early history of the movement. It had its practical beginning in Belgium in 1877, when Mr. Belpaire, the noted railway and locomotive engineer, of the Belgian State Railways, designed a special type of steam car for operating an auxiliary service on suburban lines and on sections of the main line in the thickly populated rural districts. It was also adopted for a military railway connecting the forts around Antwerp. The results were so successful that in 1880 the French government issued a decree modifying the severe regulations of the general railway law of 1846, and authorizing the Minister of Public Works to introduce on lines of light traffic (of the State Railways) a passenger service by the use of self-contained steam cars or light locomotives hauling a few cars. It also permitted the reduction of the staff to an engineman and conductor for a steam car or a locomotive with only one car. The only direct result was the experimental running of a Belpaire car on the French State Railways, but about the same time the system of light or auxiliary trains was introduced on the secondary lines of the Austro-Hungarian State Railways and for the local and suburban service of the lines entering Berlin, Germany.

In 1881, the status of this auxiliary train system in Europe, outside of Belgium, was as follows: In Austria, the system was in use on three secondary lines and for the local or suburban service of three main lines, representing 156 and 516 miles respectively. Steam cars were used in some cases, while in others special light cars were hauled by tank locomotives. In Germany, light locomotives and cars were in use for suburban and local service on four lines running out of Berlin, for distances of 7½ to 20 miles. Light locomotives and cars were used in some cases and Rowan steam cars in others. In Italy, five sections of the Upper Italy Rys. were operated by steam cars for local traffic near the large cities. These sections aggregated 95 miles in length.

In 1881, the French tests having practically come to nothing, the Minister of Public Works appointed a commission of engineers and railway officers to investigate the practice and experience of the German and Austrian lines. The commission reported that the system of operating a service of light trains on short sections of line would be advantageous, and recommended that the Department should call the attention of the companies to the matter and express its willingness to grant certain modifications of the railway regulations, as follows: 1, giving them the benefit of the decree of 1880 (above noted); 2, permitting trains to stop at certain points on the open line without installing signals, gates, or station buildings to receive and discharge passengers "without baggage and without dogs"; 3, permitting the use of two instead of three classes of passengers and not requiring these trains to carry mails, horses, etc.; 4, permitting the trains to be hauled by engines running tank first. These conclusions were adopted in December, 1881.

In 1885 and 1886, the Northern Ry., of France, was confronted by a serious reduction in traffic, and found it necessary to reduce its operating expenses, so as to keep them in proper proportion to the receipts on each part of the line. It was decided to introduce a light train service on a local section of the company's line in Belgium, in a district where the Belgian State Railways were operating light trains of two to four cars at speeds of 22 miles an hour. The section selected was between Liege and Flemalle, 7¾ miles, with four stations and six additional stops, four of which were at grade crossings. The results were so successful that the system was introduced on other parts of the company's lines, and by March, 1887, it was in operation on 16 sections, aggregating 270 miles. Half of these sections were operated by "tramway trains" (having only one car attached to the engine), and the others by "light trains" having from two to seven cars. It had also been decided to introduce the system as other lines of about the same aggregate length. At the same time the Eastern Ry., the Western Ry. and the Paris Belt Line Ry. were operating or arranging to operate the system on some ten branches or sections of line with light traffic.

The term "tramway train" is now very generally applied to the system in general, whether the actual operation is by means of a motor car or a train. The service resembles that of a tramway (or street railway laid in city streets or along country roads): the speeds and fares are low, the service is frequent, numerous stops are made, the equipment is light, freight is not carried, and fares are collected by the conductor. On the Northern Ry. the trains consisted of an engine with one to six cars, of special construction and with a kind of ball and socket coupling which made the train practically an articulated or jointed car. It is noted that while the locomotives were light, they were powerful enough to give rapid acceleration, so that in spite of the numerous stops the journey speed (from end to end of run) was relatively high. It is not necessary here to discuss the rolling stock equipment in detail. The system is still in use, but as the result of continued experiment and improvement, the train is being in some cases superseded (or perhaps supplemented) by steam cars, as described in another column. The cost of operation of these "tramway trains" including wages, fuel, oil, cleaning, heating, lighting, maintenance and repairs, is given as 13 cts. and 20 cts. per mile for trains with one car and with two to six cars, while with ordinary trains the cost per mile was from 22½ to 26 cts.

On the railways of continental Europe, the introduction of steam cars and light trains to give a good and economical service on branch lines, and to supplement the ordinary trains on suburban or rural sections of the main lines, is well established, and is a recognized feature of railway service. It receives constant and not spasmodic attention, and improvements in equipment and service are continuously being made. It is perhaps worth noting that the railways themselves have taken up the matter and have not left it to the attention of those interested in locomotive or car construction. When the initiative is taken by a manufacturer or inventor and the manager simply consents to a trial, the practical results may be disappointing, since the railway officials have probably little interest in the matter. But if the initiative is taken by a manager or superintendent, who is perhaps facing the difficulty of decreased earnings and increasing competition, there is much more determination that the methods adopted shall be made to work successfully.

As already intimated, we consider that the motor-car system offers many advantages for local railway service in this country, and that managers will in time have to give more careful attention to the local passenger traffic than has been done in the past; and also that the motor-car system offers many advantages for such traffic in this country.

If European and English railways supplying a densely populated country can operate such a system to advantage, it ought to be a still greater success in this country where on a large proportion of the railway mileage passengers are now carried at no profit or at an actual loss.

LETTERS TO THE EDITOR.

More High Steel Chimneys.

Sir: Replying to inquiry of "G. A. H." in your issue of July 21 as to the highest steel chimneys in America I would note the following high steel chimneys:

(1) Nichols Chemical Co., Brooklyn, N. Y., 310 ft. high, 35 ft. at base to 12 ft. diameter at top.

(2) Pennsylvania Salt Co., Natrona, Pa., 225 ft. high, 10 ft. diameter flue.

(3) Maryland Steel Co., Sparrow's Pt., Md., two chimneys, each 225 ft. high and 13 ft. 9 ins. internal diameter. See "Chimney Design and Theory," by the writer, p 73, for description.

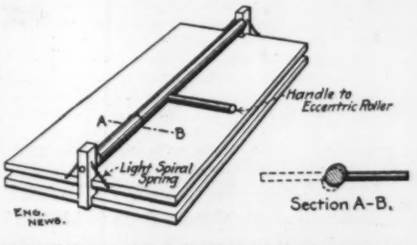
These are all that I know of outside of the steel chimneys mentioned in the query. Yours very truly,

W. Wallace Christie, Cons. Engr.

Paterson, N. J., July 22, 1904.

A Home-Made Letter Press for Camp Use.

Sir: Needing some sort of a press to copy letters I directed a camp carpenter to make me one. I enclose



sketch of the one he made, thinking that it might interest some of your readers. Yours truly,

S. O. Taylor, C. E.

Apartado 166, Monterey, Mex., June 8, 1904.

Methods of Determining the Proportion of Impalpable Powder in Cement.

Sir: For laboratory use I wish to secure some information on the best method for the determination of the very fine powder or flour in cement.

We have been using the following method: 50 gr. of thoroughly dried sample is introduced into an Erlenmeyer flask, and filtered water added, the contents are then violently agitated, and while the powder is in solution the water is poured off; this operation is continued until only the black residue is left, which is then washed from the flask onto a filter paper and dried at a temperature of 100° C. and weighed.

Our results have varied so much that I would like to have some one's experience on the same line, and if they have a different method would try it in our laboratory and exchange results.

This method is not included in our regular test for cement. I am simply trying to secure an accurate method for the determination of fineness, because I do not think the results on the 200-mesh sieve give the whole story as to the capacity of a cement for carrying sand.

Yours truly, A. W. Munsell,
Cement Inspector.

B. & O. R. R., Wheeling, W. Va., July 18, 1904.

Standardization of Hose and Hydrant Couplings.

Sir: In your issue of July 21 Mr. Loetzer, in his article on "The Standard Number Code for Couplings," refers to the unwisdom of attempting to obtain uniform hose and hydrant couplings throughout the cities in the United States. He says

such attempted change would only result in crippling and disorganizing fire apparatus and departments for an indefinitely long period of time,

giving as his reason that serious confusion would result from the use of two sizes of couplings during the transition period.

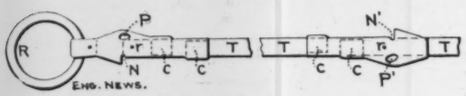
No such serious confusion as Mr. Loetzer predicts need be anticipated. With a National Standard Coupling once established by a competent tribunal every city at slight expense could provide simple bushings for connecting its local couplings with the standard. It would then be able to assist or receive assistance from any other city similarly equipped.

Any one familiar with the practice in our larger cities of using both 3-in. and 2½-in. couplings in a single line of hose knows that the serious confusion anticipated from the use of bushings or reducers, has never been found in practice. The reducing bushings mentioned above for connecting standard and local couplings are recommended to those departments which delay making a permanent change to standard couplings. The wiser cities will make use of these bushings during the brief period while their hose hydrants and suctions are being equipped with couplings of the standard pattern.

Yours very truly, Greely S. Curtis,
Corps of Engineers, National Board of Fire Underwriters.
New York, July 22, 1904.

A Tape Handle and End Marker.

Sir: The accompanying sketch shows a tape handle and end marker to be attached to an engineer's 100-ft. steel tape. At each end of the tape is fastened a brass marker, each marker being held by a rivet, r, and two clips, c c, which are bent over so as to clasp the tape, T. The 100-ft. end of the tape is provided with a ring, R, for a handle. The notch N′ is precisely opposite the zero end of the tape, and the notch N is opposite the 100-ft. end, so that the chainmen can make no mistake in holding the plumb-bob string exactly in the proper



place. By providing two pear-shaped holes, P and P′, it is possible for one man to do the chaining. A No. 16 wire brad, 1½ ins. long, is driven in each station stake, and left projecting up so that it can enter one of the holes, P or P′, thus dispensing with the rear chainman. This wire brad also makes a good transit point. By using a tape provided with these brass markers of mine as described, a transitman and one chainman can run lines accurately and quickly, and the markers will more than pay for their first cost every day that they are in use.

Very respectfully,
Thos. N. Badger, C. E.
403 East 18th St., Oakland, Cal., May 15, 1904.

What Intensity of Rivet-Bearing Stress is Allowable?

Sir: Specifications for bridgework usually lay down from 12,000 to 20,000 lbs. as the allowable crushing stress per square inch on rivets. Strict adherence to this in the design of plate girders entails closer rivet spacing at the ends than would otherwise be necessary, and in some cases the depth or thickness of the web has to be increased, which entails extra cost.

I shall be glad to know if any of your readers can cite instances of girders which have failed solely owing to the rivets or plates on which they bore, getting crushed.

This is a matter of considerable importance, sometimes, in determining whether or not an old girder shall be allowed to remain in the road under the ever-increasing engine loads. Most of these seem to have been designed without any attention to rivet spacing, and are consequently far weaker in this respect than for flange stress. I have heard of cases of bridges whose rivets are sustaining crippling stresses of 30 tons per square inch, and have been doing so for years without evincing any symptoms of distress. Of course, friction between the angle bars and the web would relieve the stress on the rivets to a certain extent, but could hardly account for the difference between 20,000 and 67,000 lbs.

Another interesting question is: Rivets getting loose at the ends of girders are generally supposed to be an indication of excessive bearing pressure though it would appear that the deformation of a rivet in any way would tend to make it still tighter.

Yours faithfully, G. A. Glascott,
Mission Road, Rangoon, Burmah, India, June 14, 1904.

(We shall be glad to hear from any of our readers who can give any information bearing on the questions raised by our correspondent.—Ed.)

Crushed Limestone Screenings, Again.

Sir: In the paragraphs taken from the Chicago Mayor's objections to limestone screenings for city sidewalk concrete, quoted in your article in Engineering News of April 28, 1904, under heading "Limestone Screenings for Sidewalk Concrete," arguments are presented that are an injustice to that material as a concrete aggregate. Your sentiment, in that article favoring screenings, is in harmony with the merits of this material as observed by the writer.

Since the publication of results of limestone screenings compared to sand in my article of April 16, 1903, various tests have been made in the cement testing laboratory of the Chicago, Milwaukee & St. Paul Ry. Co., with Mr. C. F. Loweth, Engineer and Superintendent, and Mr. J. C. Hain, Engineer of Masonry Construction.

Without an exception these limestone screening tests have shown superior to sand tests. And reports received by the writer from well governed laboratories where tests have been made of this material all indicate one fact, viz., far superior to sand as a concrete aggregate.

Tests thus far obtained (to two years) indicate screenings ranging from No. 8 to No. 4 to be the most valuable, i. e., one, all of which will pass a sieve not having more than eight meshes to the linear inch, and, one, all of which will pass a sieve not having less than four meshes to the linear inch. A finer mesh sieve than a No. 8 would tend to give a product containing an excess of impalpable "stone" dust (note I say "stone"), especially if a soft limestone is employed. A coarser mesh sieve than a No. 4 would give a product the handling of which is more or less apt to separate the coarse and the fine particles, the same way as handling crusher run limestone, especially in unloading it from car or wagon, tends to separate the coarse and the fine particles.

In passing and referring to crusher run limestone, a word might be said regarding the above-mentioned separation of the coarse and the fine particles in a crusher run product. As a concrete material, crusher run limestone is better than screened crushed limestone if it were practically possible to keep it uniformly crusher run and so incorporate it into the concrete. However, because of this unavoidable separation of the fine and the coarse particles by handling, crusher run limestone, strictly speaking, does not enter into concrete. The fine particles are in excess, or fall short. Therefore, when we figure to fill the voids in crusher run limestone we are not on reliable bases, and crusher run limestone thus employed cannot result in a uniform concrete. The writer believes a more homogeneous concrete would be obtained by keeping crushed limestone and the screenings separate and mix them in known proportions in every batch of concrete for the work, and he also believes a concrete made of cement and screened crushed limestone and enough screenings to fill voids, to make a much superior and much more uniform concrete than crushed limestone (crusher run, or screened) and sand sufficient to fill voids as above.

Coming back to limestone screenings, besides the fineness of the screenings the quality of the limestone is an important factor, very soft limestone naturally being inferior to the harder stone. Tests made here indicate that a very soft limestone should not be reduced to as fine screenings as a harder stone. With both the soft and the hard limestone crushed through same set of jaws of crusher it will be found the soft screenings contain a much larger amount of impalpable powder than the hard stone screenings. Therefore by regulating the screenings according to the hardness of the stone will tend to equalize their value somewhat as a concrete aggregate.

In article referred to above, the Mayor of Chicago expresses apprehension that limestone screenings concrete may weaken after a certain age. There is nothing to indicate this to be a possibility with limestone screening concrete any more than with a sand concrete. In both concretes the particles are enclosed in cement whose tendency is to increase in strength as the years and centuries go by.

The diagram hereto accompanied contain the results, in curves, to two years, of several mixtures of cement and crushed limestone screenings, which, compared to the sand test, carried on with the screening tests and all made with one lot of cement indicate not only a very fine and regular advance in strength, but also its remarkable superiority over sand. These diagrams show the average tenor of lime screening tests made in this laboratory.

The writer wishes to urge those interested in this line, as he did over a year ago (April 16, 1903), in this journal, to make tests of limestone screenings from limestones throughout the country, to hasten our knowledge, and to increase public confidence regarding this remarkable material as a concrete aggregate.

G. J. Griesenauer,
Cement Tester, Bridge & Building Dep.
Chicago, Milwaukee & St. Paul Ry.
Chicago, Ill., July 2, 1904.

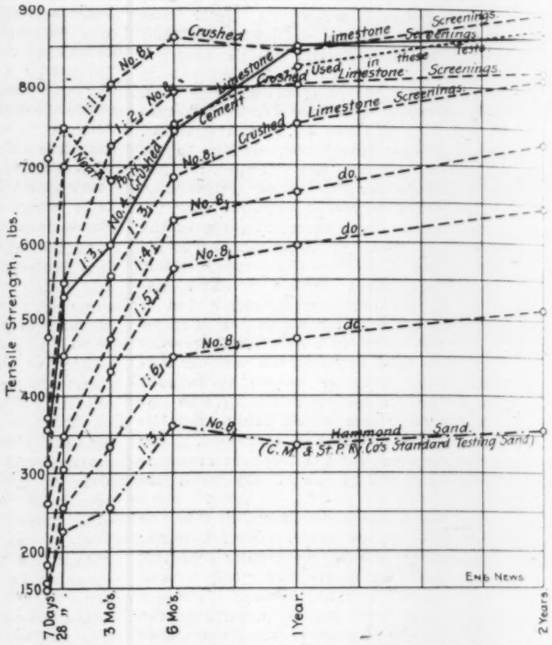


DIAGRAM SHOWING RESULTS OF TESTS OF MORTARS OF CEMENT AND LIMESTONE SCREENINGS.

Temperature Changes in the Barossa Dam, South Australia.

Sir: In your issue of April 7, 1904, I notice the statement of temperature changes in the Barossa dam, viz: A daily range of 50° caused a crown movement of ⅛ in., and the further statement that this corresponds to an expansion of about 1½ ins. This amount of expansion seemed to me so large that I was led to examine the matter, and as the results are somewhat different, they are offered for publication.

The relation of crown movement and expansion of length was shown in a paper by Herbert Vischer and Luther Wagoner (Tech. Soc. Pac. Coast, Dec., 1889) to be very closely: Expansion = ½ arc × crown movement; in this case arc 67° 40′ = 1.81 × ⅞ = 1.033 inches. On page 121 a more accurate method of computation is given, which would raise the above value to approximately 1.04 ins.

Taking the co-efficient of expansion of concrete at .0000035, .0000060, .0000065, a mean radius of 2,364 ins. and the expansion at 1.04 ins., there results temperature changes of 33.9°, 31°, 28.7°; that is to say, a daily range of 50° caused changes throughout the mass of concrete of about 30°. Taking the weight of concrete at 150 lbs. the specific heat at 0.2, there is in 3 cu. ft. 90 heat units per degree of temperature. Since a mean temperature exists, the above 30° of change can stand for the loss by cooling, the same being restored by the heat absorbed during the day, but $\frac{30 \times 90}{12} = 225$ heat units lost per square foot of surface per hour. According to Box (p. 219) a stone wall 3 ft. thick will emit from one face 0.228 units of heat per sq. ft. per hour per degree difference of temperature. Hoadley (Am. Soc. M. E., Vol. VI.) said that it was probable that a brick wall 38½ ins. thick having internal and external temperature of 400° and 100° lost or radiated 100 units per hour, which is ½ unit per degree of difference. The daily heat curve can be taken as a parabola and the semi-range as 25°. Then ⅔ 25° × 12 hours × .238 = 46.8 units lost, or $\frac{46.8}{90}$ = .52, which means that using 0.238, as above, the daily change in the top mass of the wall was about ½°. Granting that this value 0.238 is several times in error, it does not appear probable that any expansion in length of the dam can account for 10% of the ⅞-in. of movement. By the same course of logic we may exclude heating of the skin to a small depth and causing the work to be done by the superficial layers. There appears to be, then, but one possible solution, which is that the most of the ⅞-in. was caused by buckling of the dam, without any real increase of length. The top of the dam may be

considered as a curved elastic beam in unstable equilibrium readily deformed by relatively slight forces without any material or even no increase or decrease of length. In such case a plus movement at the crown would have zero and minus movements near the ¼ and ¾ points, respectively. The slight changes in length, aided, perhaps, by an unequal heating of the skin, are sufficient to cause such changes. Observations upon this dam, both in a loaded and unloaded state, at ⅛, ¼, ½ arcs, and especially if temperature were taken at one or more points in the mass, would afford valuable data to the profession. If the above explanation is correct it is a strong argument in favor of the curved type, since it disposes of temperature strains in a manner not possible in dams of the straight type.

Luther Wagoner.

849 Chestnut St., San Francisco, Cal., April 22, 1904.

(The foregoing letter was at once forwarded to South Australia. Mr. Moncrieff's reply follows.—Ed.)

Sir: I am much obliged for your courtesy in forwarding to me for my information and remarks the letter addressed to you by Mr. Luther Wagoner, of San Francisco, in reference to the movement of the crest of the Barossa Dam, described in Engineering News of April 7.

I am afraid that in writing my notes for you originally, I was not sufficiently explicit in reference to this matter, and have now much pleasure in giving the remarks of the Resident Engineer, which fully describe the temperature conditions under which the expansion referred to actually took place:

With reference to the question raised regarding expansion, I may state that the argument in Mr. Wagoner's letter of April 22 is based upon a misconception of the manner in which the expansion on the dam was ascertained, and it is due to the abbreviated form in which the records were explained in the article. Mr. Wagoner is under the impression that the expansion of ⅞-in. on the crown of the arch was produced in twelve hours by the extremes of temperature in one day, and he has shown that the extent of cooling which could possibly take place in such a wall under these conditions is insufficient to produce so large an expansion. The measurements, however, recorded not the expansion of the day, but the expansion which was gradually produced by a severe change in the weather extending over an interval of six days. On six days preceding the first measurement the temperature day and night had been fairly uniform and the average was taken. This was followed by extremely hot weather in which the mean average temperature was 50° higher, causing the wall to gradually expand until the maximum of ⅞-in. was reached at the end of the period. It will thus be seen that the calculations of Mr. Wagoner, based upon the supposition that the expansion was produced in twelve hours, is inapplicable to the case, and it seems probable that the whole of the movement was due to actual expansion of the wall and not to buckling, as suggested. This is further borne out by the fact that the measurement was made not at the crown of the arch, but at a point opposite the valve tower, where ¼-in. was the outward movement. If the movements had been due to buckling of the wall, this is very near the point where Mr. Wagoner suggests the movement might be zero.

From the above it will be seen that the daily variation must have been very slight, although it was not actually measured, not being considered of sufficient importance in view of the uniform character of the weather during the week referred to.

Under existing weather conditions it is quite impossible to make the experiments now which Mr. Wagoner suggests, but I agree with him that it would be exceedingly interesting when the opportunity arises if such experiments could be carried out. I am, dear sir,

Yours faithfully, Alex. B. Moncrieff,
Engineer-in-Chief for South Australia.

Adelaide, S. A., June 8, 1904.

Copper Sulphate as an Algaecide.

Sir: My attention has recently been called to the article and the editorial note in your journal of July 14, relative to the use of copper sulphate for the destruction of algae in water reservoirs.

I was much interested in reading the account of the experiment at Elmira, N. Y., by Mr. James M. Caird, but regret very much that he failed to communicate with us before making the treatment. As I have written to Mr. Caird, the same beneficial results might have been obtained at about one-tenth of the cost, and without the destruction of any fish. It is necessary that the specific condition of the water, the organism to be destroyed, etc., be taken into consideration, and with the rather large amount of experience we have obtained in treating reservoirs throughout the country, we feel that we are able to be of considerable assistance to engineers and others who may have occasion to use the method.

The amount of copper sulphate used by Mr. Caird was in excess of the maximum treatment ever made by us, and it is difficult to understand why he should have added the quantity he did. The reason we gave no more specific directions in the bulletin recently published was because we hoped that experimentors would communicate with us before attempting to exterminate algae.

You are in error in thinking that the case reported by Mr. Caird is the first one where the method has been given a practical trial (we said since the publication of the Bulletin.—Ed.). We hope at the end of the season to publish a list of the reservoirs that have been treated in the last two years, and to give a full account of the methods used and the results obtained; therefore, at the present time I can only say that we have been successful in destroying the growth of algae in reservoirs of at least several towns in ten different states, and the results have been as satisfactory when treating 600,000,000 gallons as in reservoirs of smaller capacity. You will probably be interested in knowing that the supply at Winchester, Ky., which was referred to in the bulletin, still remains perfectly free from algae, although treated more than a year ago, and it was one of the worst cases ever brought to our attention. Similar results elsewhere would seem to indicate that the permanence of the treatment is greater than we anticipated. I am,

Yours very truly, George T. Moore,
Physiologist and Algologist, U. S. Department of Agriculture.

Woods Hole, Mass., July 20, 1904.

The Use of Copper Sulphate As An Algaecide At Cambridge, N. Y.

Sir: I was very much interested in the article in Engineering News of July 14 regarding the use of sulphate of copper at Elmira, N. Y. I recently received a letter from my father, C. T. Hawley, of Cambridge, N. Y., saying that they had used sulphate of copper in their waterworks reservoir to get rid of an unpleasant taste and odor which was evidently caused by a growth of algae, and the sulphate of copper accomplished the purpose perfectly. I would suggest that you might get from him some details, although no microscopic or bacterial investigation was made.

The water supply of Cambridge is obtained from springs which have been impounded by the construction of a reservoir embankment about 12 ft. high, the water covering about an acre of area, and being from 6 to 9 ft. in depth. From this reservoir there is a flow of about 1,000,000 gallons per day. Power is developed by a back-pitch water wheel, and some 40,000 gallons per day pumped to the village, or to a reservoir on a near-by hill which is fed from a small stream, and which supplies fire protection in case the demand exceeds the capacity of the pumps at the lower reservoir. There has also (always? Ed.) been a heavy growth of algae in the lower reservoir, but never any odor or taste from it until last summer. Prior to that the growth seemed to "ripen," float to the surface, and it was then blown ashore, raked up and taken away. Last year, however, instead of floating it sank to the bottom and seemed to decay, and it was necessary to drain the reservoir and clean it. The taste and odor have occurred slightly several times since, and about the middle of June became very bad. About that time a newspaper account of the sulphate of copper remedy was noticed and the bulletin from the U. S. Department of Agriculture was obtained and the process tried with success.

It seems, therefore, that it is a question whether Elmira or Cambridge was the first to try this new remedy.

Yours very truly, W. C. Hawley,
Gen. Supt. Pennsylvania Water Co.

Wilkinsburg, Pa., July 16, 1904.

(Acting upon the suggestion made in the foregoing letter we wrote to Mr. Hawley, of Cambridge, and received the interesting letter that follows.—Ed.)

Sir: In reply to your inquiry requesting the results of the use of copper sulphate as an algaecide I will say it is a complete success. We have two reservoirs. One we had to clean last November on account of the algae, which gave a very fishy taste to the water. In a month's time after cleaning the algae was growing again worse than before the reservoir was cleaned, and it continued to grow all through the winter.

We had just decided it necessary to clean the reservoir again when I saw an article in the New York "Tribune" giving some account of the experiments made by the U. S. Department of Agriculture for the destruction of algae in water-works reservoirs. I obtained a copy of the pamphlet issued by the Department and secured the services of Mr. Frank Richardson, a chemist of this place, who treated our reservoir on June 2, 1904. The reservoir holds about 1,250,000 gallons. We used 10 lbs. of the copper sulphate, costing 80 cts. The effect was almost immediate. In half an hour's time we could see a change in the appearance of the algae, which grew 3 or 4 ft. high in the reservoir. We treated the reservoir about 4 p. m. The next morning the algae was dead and lying on the bottom of the reservoir. In three or four days it entirely disappeared. The reservoir was left in fine condition and has remained so since, with no indications of further growth.

As the algae began to grow in our other reservoir we had that treated the last week in June with the same result as with the first reservoir. Our second reservoir holds about 3,000,000 gallons. We used 20 lbs. of the sulphate of copper for it.

In the first reservoir we have native trout. The sulphate did not kill them. In the other reservoir it killed a few small minnows which were in the shallow water near the banks, but not any that were in deeper water. We threw them out on the banks where the crows ate them up without any serious effects on the crows.

In treating the reservoirs we placed the copper sulphate in a bag made of burlap attached to a small rope. Two men, one on each side of the reservoir, pulled the bag back and forth through the water, moving the bag along on the rope about 15 or 20 ft. each time across. We adopted this form as our reservoirs are only about 200 ft. across. The water is from springs in the bottom of the reservoir flowing from 2,500,000 to 3,000,000 gallons a day at a temperature of 48° F. No filtering is necessary as analysis shows it as pure water as any known. We had no analysis of the water made either before or after the treatment.

Yours truly, C. T. Hawley,
Secy. Cambridge Water-Works Co.

Cambridge, N. Y., July 22, 1904.

(The reservoir at Elmira was treated on June 25, 1904, or some three weeks after the first of the two reservoirs at Cambridge. It will be seen by the accompanying letter from Mr. Moore that reservoirs have now been treated in ten different states. According to the local papers of Springfield, Mass., the process is to be or has just been applied there by Mr. Kellerman, who was associated with Mr. Moore in the preparation of the bulletin reprinted, in large part, in our issue of May 26.—Ed.)

Notes and Queries.

M. L. C. wishes to know whether any experiments have ever been made with granitoid as a lining for inverts of storm sewers. He is considering the use of a granitoid line in sewers of 4 to 6 ft. diameter, grades ranging from 0.2 to 1.3 ft. per 100.

"Q" writes us, asking the following rather ambiguous question:

What is the transverse working stress per square inch of Portland cement concrete (1:2:4) setting two weeks? Setting one month? I find it ranging in books from 20 lbs. to 200 lbs.

The words "transverse working stress" may mean allowable shear or they may be taken to mean modulus of rupture under transverse loading. If the latter, the reply is that the modulus of rupture depends upon the dimensions of the beam. If shear is meant, it may be said that working intensities as high as 200 lbs. are never used in practice. In this country 50 lbs. per sq. in. is about the highest value for safe shear used in practice. In Europe the safe shear is often limited to much lower values, as low as 20 lbs.

A COMPROMISE OF ONE OF THE SEPTIC TANK INFRINGEMENT SUITS AT PLAINFIELD, N. J.

The city of Plainfield, N. J., has settled by agreement one of the suits brought against it for alleged infringement of patents on processes of treating sewage and in so doing has secured a partner for the defence of the other and earlier suit. In 1902, Plainfield put in operation covered septic tanks and contact beds in place of the intermittent filtration plant used since 1896. In 1903 the American Sewage Disposal Co. of Boston brought suit against the city for alleged infringement of patents controlled by it and on Jan. 19, 1904, the Cameron Septic Tank Co., of Chicago, Ill., also brought a suit alleging that the city was infringing U. S. patent No. 634,423, granted on Oct. 3, 1899, to Cameron Commin & Martin, of England. On July 5, 1904, the city council of Plainfield approved a recommendation of its committee on streets and sewers that the suit be amicably settled on the following terms:

The city agreed to pay the company $4,000 for the right to use U. S. patents Nos. 634,423-8, inclusive (Oct. 3, 1899), 646,927-9, inclusive (April 3, 1900), and 663,623 (Dec. 11, 1900). The city also specifically acknowledged the validity of the patents named, and especially of the first one, which relates to the septic tank. Finally the city agreed to continue to defend the suit brought against it by the American Sewage Disposal Co., provided that company proceeds with it.

The Cameron Septic Tank Co., besides licensing the city to use the patents already named, agreed to furnish the city, on request, with plans and advice for the enlargement, under the patents, of the sewage disposal plant of the city, the company to make no charges for professional services but to be reimbursed for traveling and incidental expenses, and for "any and all disbursements incurred in the preparation of such plans." The company agreed to discontinue its infringe-

ment suit and to defend any suits hereafter brought against the city which involve devices or processes covered by the patents already named. As to the suit of the American Sewage Disposal Co., now pending, the Cameron Septic Tank Co. agreed to pay any resulting judgment against the city in so far as the judgment is based on any apparatus or process covered or purporting to be covered by the patents named. The company further agreed to assist the city, in case the suit in question is proceeded with, to the extent of "advice and the result of its experience," but not to the extent of engaging counsel or contributing money towards the defense, nor even paying its own traveling and incidental expenses.

We are informed that the city has paid the license fee and we understand that the city has accepted a surety company guarantee of the contract to the extent of $4,000, limited to a period of seven years.

For a year or so little or nothing appears to have been done in the suit brought against the city by the American Sewage Disposal Co.

THE NEW HAVEN AND NORTHAMPTON CANAL.

The history of a lost canal is given in a late issue of the "Springfield Morning Union," of Springfield, Mass. This is the canal that once connected New Haven with Northampton, and was originally looked upon as a link in a chain of canals extending to Canada.

This New Haven and Northampton Canal grew out of the Farmington Canal Co., and the Hampshire & Hampden Co., the first chartered by Connecticut in 1822, and upon which work was commenced in 1825. In 1823 the Farmington Canal route was surveyed by Benjamin Wright and his son Henry, and its cost was estimated at about $500,000, exclusive of land damages, but including a branch to New Hartford. Ground was broken on July 4, 1825, under David Hurd as Chief Engineer and Henry Farnham as assistant. On May 8, 1826, the stockholders voted to merge the company with the Hampshire & Hampden Co., and early in 1828 the canal was opened to Cheshire, and in the same year as far as Farmington. In 1829 the city of New Haven subscribed $100,000 to relieve the company from its financial embarrassments, and in the same year the Hampshire & Hampden Co. completed its canal from the Connecticut line to Westfield, thus opening navigation from the Sound to the latter place.

The canal was opened in 1830, and until 1836 a large amount of business was done; but in 1836 losses from freshets and other causes, amounting to $769,931, embarrassed the company, and, as a result, a new company was formed—the New Haven & Northampton Canal Co.

The Hampshire and Hampden Canal was chartered in 1823, and organized in 1826. The canal was built by contract, entered into in 1826. By the terms of this contract the contractors were to receive $190,000 cash and 1,000 shares of stock, and the canal was to be finished in 1829. Early in the latter year it was seen that the contractors could not finish on time and could not pay their instalments on the shares held by them. The canal was built to a mile and one-half above Westfield; but here the work stopped until 1832, when a loan of $100,000 from the City Bank of New Haven and $60,000 raised along the line enabled them to resume work, and the canal was finished in August, 1835. But, like the Farmington Co., the Hampshire & Hampden Co. became involved in debt, and when the two were merged into the New Haven & Northampton Canal Co the total loss of the two original companies amounted to $1,039,041.62.

The new canal company used boats of 20 to 25 tons burden between New Haven and Northampton, and very good business was done until 1838. But freshets again caused embarrassment. In 1840 the company passed under a new management, and business increased. In 1847 work was commenced on a parallel railway, and this was finished to Collinsville in 1850. This event practically marked the end of the canal business, and at the present time, for long stretches, there are no indications of the previous existence of this canal, which was a financial mistake from the beginning.

BIDS FOR A REINFORCED CONCRETE STAND-PIPE are invited by the water board of Attleboro, Mass., until Aug. 10, 1904. Snow & Barbour, Tremont Building, Boston, Mass., are engineers to the board, and have prepared general specifications for the structure. It is intended, however, to allow bidders, subject to general conditions, to make their own plans and specifications for the structure, but more particularly for the type and details of the reinforcement, the proportions of concrete and the methods proposed to make the structure water-tight. The contractor must guarantee the water-tightness and the safety of the stand-pipe for one year, and must also maintain it a year, both from the date of completion. The bids will be considered on the basis of cost and on the relative value of the bids, as presented from the standpoint of strength and probable absence of leakage, as indicated by the specifications describing the proposed method of construction as submitted by the bidder. The lowest bid will not necessarily be accepted.

The stand-pipe is to be 50 ft. interior diameter, 103 ft. high from the top of the foundation, and the walls at the bottom must be at least 16 ins. thick. It is to be covered with Guastavino tile roof. Among the requirements for cement and concrete are the following: Not more than 5% of the cement, by weight, shall remain on a 100-mesh sieve, and not more than 24% on one of 200 meshes per lin. in. The contractor must specify the quality and the size of grain of the sand to be used for the concrete; the proportions of cement, sand, and aggregate for the concrete; the method of mixing the concrete, and also of placing it in the walls; the means to be adopted for making the concrete impervious; how, if at all, he proposes to add lime to the mortar; and, in case soap and alum are to be used, whether they will be confined to the plastering coat or be embodied in the wall.

THE SIMPLON TUNNEL south heading (only the south end is now being worked) was advanced 597 ft. in the month of June, 1904, which corresponds to an average daily progress of 19.9 ft. The heading lay in calcareous schist, in which machine drilling was used throughout the month. The total length of headings on June 30 was 62,631 ft., leaving 2,083 ft. still to be penetrated.

THE HYDRAULIC LIFT LOCK for the Trent Canal at Peterborough, Ontario, was formally opened for traffic on July 9, 1904. This lock has two chambers 140 × 33 × 9 ft. 10 ins., set side by side and working up and down between guide piers of concrete. The guide piers are located midway of the length of the chambers and there are three of them. The chambers are each carried on the upper end of a plunger, the cylinder for which extends deep into the ground beneath the bottom of the lower reach of the canal. The chambers are constructed of steel plate and are carried by cantilever trusses which are balanced on the plungers. A gate closes each end of the chambers and the adjoining ends of the upper and lower reaches. The total lift of the lock is 65 ft. A complete description of this structure will be published in a future issue. The engineer of the lock was Mr. Walter J. Frances, Peterborough, Ontario.

STONE ARCH BRIDGES and retaining walls are being built by the Chicago & Northwestern Ry. under conditions where many other railways are using concrete, but it is stated that the work is being done at a cost less than that of concrete. At Milwaukee the track depression work requires retaining walls 21 ft. high, which are being built of dimension limestone. All this work is being done by the company's forces, instead of by contract.

THE PASSAIC VALLEY TRUNK SEWER legislation is constitutional, according to a decision just rendered by the New Jersey State Supreme Court. One of the three judges who passed on the case, however, held the legislation unconstitutional, and it is generally considered as certain that the case will go up to both the New Jersey Court of Errors and Appeals and to the courts of the United States. The decision just rendered involved no engineering points whatever, but related wholly to governmental questions like special legislation, powers of taxation and interference with local affairs. The present litigation is in behalf of the city of Paterson, which does not wish to be compelled to bear a portion of the expense of the trunk sewer. New York State has a commission of engineers and others, appointed many months ago, to report on the probable effect of the proposed discharge of the untreated sewage of Newark, Paterson and other municipalities into New York Bay. It is expected that the commission will report within a few months, and that the report will be strongly against the project.

WATER POLLUTION BY OILY WASTES from gas-works at Providence, R. I., is held responsible, in a recent report, for a large amount of damage to the oyster and allied industries of that section. The committee consisted of Messrs. James C. Collins, W. T. Lewis and O. P. Sarle, who reported to the Rhode Island Commissioners of Fisheries. The full report may be found in the Providence "Journal" for July 16, 1904.

SEWAGE FARMING AT HOUSTON, TEX., has been recommended by Mr. F. L. Dormant, City Engineer. The sewage is now treated by intermittent filtration, the beds for which occupy only a small portion of the 172 acres of land acquired by the city for sewage disposal purposes.

AN OUTBREAK OF TYPHOID FEVER at the State Hospital for the Insane, at Mendota, Wis., is attributed to the use of sewage-polluted water. It appears that the hospital has two sources of water supply: an artesian well, designed for drinking and culinary purposes, and an intake extending into the lake, supposed to be used for sprinkling and like purposes only. The sewage of the institution is discharged in shore from the water intake, and it is claimed that the water intake pipe leaks. The patients and employees of the hospital, it is said, preferred the lake to the artesian water, and drank it regardless of warnings to the contrary.

RECORDS OF THE FLOW AND USE OF WATER IN Colorado are being made under the direction of Prof. L. G. Carpenter, State Engineer of Colorado. A study of the Arkansas River for a distance of 300 miles is being made by means of a special service organized in March and April, 1904. The 300 miles of the river has been divided into six sections with from 6 to 13 gaging stations on each. The water commissioners and other observers report daily the gage heights and discharges at each station. In the case of reservoirs and canals, both the inflow and outflow are reported. In addition to this special study of a portion of one stream, weekly reports from each water district of the State are made by the respective water commissioners to the proper irrigation division engineer, of which latter there are five, or one for as many districts. These reports show, as averages for the week, the quantities of water entering the district from various sources, including streams, seepage and storage. The reports also show the amounts of water stored, used in irrigation, passed on to other districts and otherwise used. Other data on the reports are crops being and next requiring to be irrigated, quantity of water required and available, weather conditions and the like.

AN ATTACHMENT FOR AIR-BRAKE ANGLE-COCKS has been recently invented by Mr. Fred B. Morrison, for four years an air-brake expert on a railway instruction car. The attachment consists of a valve, which causes a service application instead of an emergency application of the brakes, to be made in case the train breaks in two and a hose parts or comes off. This valve forms part of the ordinary angle cock. Normally the valve remains open, and is not affected by service or emergency application of the brake. In case of breakage of the hose, however, the valve is automatically closed, and the escape of the air is so checked that only a service application of the brakes takes place.

The particular advantage claimed for this attachment is that it eliminates the severe shocks which occur when a heavy freight train breaks in two, as well as the collisions which usually occur between the two parts after separating. Successful tests of the device were made in presence of a large party of railway officials at Columbus, O., on July 13. The valve is to be put on the market by the Morrison Automatic Safety Valve Co., of 338 Huron St., Toledo, O.

THE WORK OF EXCAVATING THE "AMBROSE" channel of 40 ft. depth across the outer bar of New York harbor is to be expedited by two large Government seagoing hopper dredges in addition to the plant operated by the contractor, Andrew Onderdonk. One of these new dredges, the "Manhattan," was launched at the Maryland Steel Co.'s shipyard on July 9.

A UNIVERSAL AND INTERNATIONAL EXHIBITION is to be held next year at Liege, Belgium, in celebration of the 75th anniversary of Belgian independence. The exposition will open in April or May of 1905, and will continue until November. It is under the patronage of the king, and a government commission has been formed to co-operate with the exposition company in arranging the details of the enterprise. The commission is headed by Mr. R. Lamarche, and Mr. J. Gody is secretary. The president and secretary of the exposition company are Mr. Emile Digneffe and Mr. Paul Forgeur.